ESSAYS ON PRICING IN TELECOMMUNICATIONS

BY

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The first essay develops and tests a model of state price regulation based on the economic theory of regulation. The empirical analysis finds that state statutory allowance of facilities-based intraLATA toll competition is not a major force that drives toll prices lower (in the 48 contiguous United States over years 1983-1992). The analysis presents new evidence that toll rates are significantly lower in states where threats of entry from competitive access providers and cable television are greater. Furthermore, this study provides comprehensive evidence that intraLATA toll rates are lower in states where consumers are more sensitive to higher rates.

The second essay explains why the FCC's price-cap plan for regulating AT&T may lead to intertemporal incentive problems that can be costly to society. Under price-cap regulation of baskets--groups of services--a weighted average of the prices for all services in a basket must not exceed a specified level. As demand becomes less elastic, the firm is shown to have a greater incentive and ability to exploit the weight structure for profit. This analysis identifies specific conditions under which weight manipulation occurs, examines the welfare implications of weight manipulation, and proposes an alternative weighting scheme that eliminates the incentives for weight manipulation. Since social welfare is shown to decrease unambiguously with weight manipulation, the alternative weighting scheme can improve social welfare.

The third essay revisits the oligopoly problem in antitrust. The traditional oligopoly problem in antitrust enforcement is that noncompetitive economic behavior may prevail in concentrated industries without any apparent collusion among firms and, therefore, may fall beyond antitrust prosecution. After reviewing the relevant antitrust legislation and legal thinking in antitrust since the 1960s, the paper develops and presents a stylized model of price announcements in the Ethyl case: the most prominent, recent antitrust case involving practices that facilitate tacit collusion.

CHAPTER 1

GENERAL INTRODUCTION

Pricing strategies and incentives are central considerations in regulated industries and in deciding whether industry behavior is anticompetitive. With a variety of well-defined markets, large firms, and regulatory mechanisms in place, the telecommunications industry in particular offers an excellent laboratory for selecting specific cases to model and analyze. Using empirical, theoretical, and case study techniques, the objective of each essay is to examine the pricing behavior of firms subject to regulatory or legal constraints, with particular emphasis on the telecommunications industry. The unifying theme throughout is that underlying or initial economic conditions influence the pricing incentives of the firm under any constraint.

Since the divestiture of AT&T in 1984, state-level regulation has played an increasingly larger role in the telecommunications industry. The markets for telecommunications services have grown considerably, and rapidly changing technologies and market structures are outpacing regulatory constraints. Much of the economic literature that describes telecommunications markets offers conflicting results and generally neglects the role of consumers as political agents. Based on the economic theory of regulation, the first essay develops and tests a model of state price regulation. In the economic theory of regulation, policy-makers maximize political support, and outcomes of their decisions depend upon the relative strengths of opposing interest groups. The first essay focuses upon just one of the intrastate telecommunications markets: intraLATA toll calls in the 48 contiguous United States over years 1983-1992. The essay presents interesting findings about the impact of actual and potential competition in this market and offers strong evidence that the relative strengths and interests of firms, consumers, and policy-makers have explanatory power for telecommunications markets.

The divestiture of AT&T also has contributed to the need for new forms of federal telecommunications regulation. Since 1989, AT&T has been subject to price-cap regulation, where the average price for different groups or baskets of services must not exceed a level that is tied to an index of inflation. To calculate the average price, the share of total revenue generated by a service today is used to weigh the contribution of a service towards satisfying the cap tomorrow. The second essay examines in detail ways by which AT&T and other firms subject to this common revenue-weighted form of price-cap regulation might exploit the weighting scheme over time. The essay demonstrates specific demand conditions under which weight manipulation becomes profitable, shows that the manipulation reduces consumer welfare, and identifies an alternative weighting scheme that does not provide incentive for manipulation.

The interstate telecommunications industry has been characterized as an oligopoly where AT&T is the price leader. The third essay revisits the traditional oligopoly problem in antitrust that noncompetitive economic behavior may prevail in concentrated industries without any apparent collusion among firms and, therefore, may fall beyond antitrust prosecution. After reviewing the relevant antitrust legislation and legal thinking in antitrust since the 1960s, the paper develops and presents a stylized model of price announcements in the Ethyl case: the most prominent, recent antitrust case involving practices that facilitate tacit collusion. The central finding of the essay is that while explicit modeling of firm and industry behavior may shed light on the price outcome, the theoretical results are highly dependent upon the assumptions of the model. The details of individual cases are crucial to any finding that firm or industry behavior is anticompetitive.

CHAPTER 2

INTRALATA TOLL RATES: TESTS OF A POSITIVE MODEL OF REGULATION

> It wasn't the RBOCs that killed [legislation] . . . it was the system and those who feed myths into the system . . . the rejectionist front--namely the long distance industry teamed up with the cable business. . . . In the recently deceased Senate legislation, [special interests] had the audacity to suggest that a reseller, without any facilities investment whatsoever, could get all the unbundled pieces from you and then get protected as a carrier of last resort. That's a transparent scheme to let sharpies, who never invested a dime in the national infrastructure, mine wealth out of the investments of others. Incredibly, some policy-makers bought off on it.
>
> Phillip Quigley
> Pacific Telesis CEO
> Keynote speech, USTA convention
> San Diego, CA. October 10, 1994.

2.1. Introduction

There is considerable debate about the extent of competition in telecommunications markets.[1] While much recent attention has focused upon competition in interstate (interLATA) long-distance and basic local service markets, competition in the market for intrastate (intraLATA) long-distance service also has emerged as an important consideration.[2,3] The Bell Operating Companies (BOCs) account for the vast majority of intraLATA toll calls, and this large market represents over $10 billion in 1993 BOC revenues.[4,5] Since 1983, most states have opened intraLATA toll markets to meaningful forms of competition, and the price of an average intraLATA call has fallen about 13% in real terms.[6] Empirical evidence on the impact of competition upon prices is mixed, however, and no study has carefully identified the underlying determinants of intraLATA toll rate differences among states. This analysis provides comprehensive evidence on the basic determinants of intraLATA toll rates.

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[1] For different viewpoints, see Sievers (1994), Hall (1993), Huber (1992), and Taylor (1993).

[2] The *Modification of Final Judgment* that ended the antitrust case against American Telephone and Telegraph (AT&T) in 1982 created 161 geographic regions called local access transport areas (LATAs) based largely on population density and calling patterns. The Bell Operating Companies are allowed to provide only intraLATA long-distance services.

[3] No state currently allows intraLATA toll calls to be routed to carriers other than the local exchange carrier (LEC) on a 1+ dialing basis. The most common requirement is that consumers dial an access code, such as 10XXX, to route the call to another carrier. Dialing parity--1+ competition--is a precondition for BOC entry into interLATA markets in the failed bill S-1822, as approved by the Senate Commerce Committee (Bureau of National Affairs, August 18, 1994).

The theoretical model that underlies the empirical analysis in this research is based on the economic theory of regulation.[7] In the economic theory of regulation, policy-makers maximize political support, and outcomes of their decisions depend upon the relative strengths of opposing interest groups.[8] Peltzman's (1976) "Stiglerian Model of Regulation" explicitly specifies some factors, such as lobbying and education, that may influence whether constituents vote for a regulator (or a public servant who appoints a regulator). Previous research on intraLATA toll rates has not been based on the economic

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[4] The seven regional Bell operating companies accounted for 75% of long-distance message revenues (Class A) in 1991 (FCC, 1991). Revenue percentage calculated as toll network revenue divided by net revenue (subject to separations) for all BOCs and SNET (FCC ARMIS 43-01 reports for 1993, Table 1).

[5] States that allowed facilities-based intraLATA toll competition in 1983 were FL, IA, MD, MT, NY, SC, TX, WA, and WY (NARUC 1983). The only states not to allow facilities-based intraLATA toll competition in 1993 were AZ, AR, CA, HI, NJ, NC, and OK (NARUC 1993c).

[6] The percentage price change is computed using a five-minute, day-time call averaged over eight different mileage bands and 48 states in 1983 and 1992. Nominal prices are adjusted by the consumer price index.

[7] Caudill et al. (1993) formally test specifications of seven alternative models and conclude that the economic theory of regulation consistently outperforms alternative theories and "rules of thumb" for explaining regulatory behavior.

[8] See Stigler (1971), Posner (1974), and Peltzman (1976).

theory of regulation.[9] The present model and empirical analysis identify the effects of state demographics, politics, actual and potential competition, and regulatory policies that influence how responsive constituents are to prices when voting. The approach here also departs from those of previous studies by not including either past rates or prices from related telecommunications services as explanatory variables. While including prices in this manner may shed light on the impact of certain policies, a concern is that all prices might be explained by the same underlying factors, and these factors are what drive the rate differences among states.[10,11]

A central finding is that state statutory allowance of facilities-based intraLATA toll competition is not a major force that drives toll prices lower (in the 48 contiguous United States over years 1983-1992), even when the market size is taken into consideration. The analysis presents new evidence that toll rates are significantly lower in states where threats of entry from competitive access providers and cable television are greater; entry by these competitors may take with it the revenues earned in the markets for toll, basic local service, and access.[12] Furthermore, this study provides strong evidence that intraLATA toll rates are lower in states where "consumers" are more sensitive to higher rates. Specifically, intraLATA toll rates are found to be significantly lower in states with (1) elected regulatory commissioners, (2) Republican control of state government, (3) higher income, (4) less rent-seeking in the state legislature, (5) lower costs of living and more temperate climates, and (6) more large industrial consumers. The measures of Republican party control, rent-seeking, climates, and entry by competitive access providers and cable television are new contributions to the literature on telecommunications prices.[13] While offering many new insights, the results of this analysis are in line with previous findings. The findings that Republican control and higher income correspond with lower intraLATA toll rates are both consistent with existing evidence that the demand for intraLATA toll calls is income elastic in the long-run. The result that facilities-based intraLATA toll competition does not lead to significantly lower rates is consistent with that of Kaestner and Kahn (1992), the only other study to examine rates over time (1986-1990).

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[9] The best study of intraLATA toll prices to date, the 1986 cross-sectional analysis of Mathios and Rogers (1990), includes some measures of state demographics and regulatory climates but never attempts or claims to test the economic theory of regulation. In more general contexts, Kaserman et al. (1990) and Kaestner and Kahn (1992) test the same theoretical model. Both studies refer to Peltzman (1976) but maximize a utility function for the regulator like that discussed by Evans and Garber (1988); Evans and Garber (1988, p. 445) note that their objective function is "very different" than that used by Peltzman.

[10] Mathios and Rogers (1990) include 1983 toll prices to explain those for 1986; Kaserman et al. (1990) include the common carrier line rate (access price), local rates, and intrastate toll subsidies per residential customer. Kaestner and Kahn (1992) include the prices of access, local, and toll.

[11] Looking beyond analyses of toll prices, there are tests of the economic theory of regulation related to the intrastate toll market. In a discrete choice model about deregulation of AT&T (intrastate, interLATA), Kaserman et al. (1993) conclude that the economic theory of regulation outperforms the public interest theory. In another discrete choice model (change in intraLATA rate structure), Teske (1991a and 1991b) relies partially upon the economic theory of regulation to test an interest group theory but omits economic measures of state demographics and firm costs. For empirical tests of the Peltzman/Stigler theory in other industries, see Caudill et al. (1993), Delorme et al. (1992), Im et al. (1989), Becker (1986), and Primeaux et al. (1984).

The paper is organized as follows. Section 2 presents the theoretical model and its testable predictions. Section 3 contains the empirical analysis. Section 4 offers conclusions and directions for further research.

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[12] As described by Seidenberg (1994), "competitive access providers are beginning to offer communications services that can be routed by various switches without ever touching the local exchange company . . . [Offering both voice and video services], cable companies will be able to offer a complete alternative to the local exchange company."

[13] In a cross-sectional analysis using 1984-1986 data, Teske (1991a and 1991b) includes Fortune Service 450 headquarters, party control of the state legislature, elected/appointed commissioners, and cable penetration. Teske accounts for various interest groups but omits economic measures of state demographics and firm costs.

2.2. Model of Price Regulation and Testable Implications

This section describes a model of price setting in a state regulatory environment. The model draws from Peltzman's (1976) work, which formalizes some of Stigler's (1971, 1962) work on the economic theory of regulation.

Framework and Equilibrium

In the model, the regulator has authority to choose a price and is assumed to maximize net voting (NV) support from consumers and suppliers, where

NV = net votes for the regulator

= votes for - votes against.

If the regulator is appointed by the governor or legislature, the electorate considers the regulated price when deciding how to vote. Let superscripts "C" and "S" represent [C]onsumers and [S]uppliers. Subscripts denote partial derivatives throughout the analysis. The net votes for the regulator from consumers and suppliers are denoted as NV^C and NV^S, respectively, so[14]

$$NV = NV^C + NV^S \,. \tag{2.1}$$

The regulator's electoral support from each group depends on the price the regulator chooses.

Consumer net voting support is assumed to be an increasing function of consumer surplus (CS). Consumer surplus represents the value consumers derive from consuming the regulated product, above and beyond what they pay for the product. Letting Q(p) represent downward-sloping demand, consumer surplus is given formally by $CS(p) = \int_p^{\infty} Q(\tilde{p})\, d\tilde{p}$, with $CS_p = -Q(p)$. Consumer net voting is then

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[14] For convenience, suppose as does Peltzman (1976) that ignorance does not lead to perverse voting.

$$NV^C = NV^C(CS), \text{ where} \tag{2.2}$$

$$NV^C_{CS} > 0. \tag{2.3}$$

The extent to which greater consumer surplus translates into votes for the regulator, given by the function NV^C_{CS}, depends on the underlying characteristics of the population. These characteristics are described below.

A complementary structure for supplier voting support assumes that the quantity of net votes from suppliers increases in profit (π): Formally,

$$NV^S = NV^S(\pi), \text{ and}$$

$$NV^S_{\pi} > 0. \tag{2.4}$$

Profit equals revenue less production costs. Production costs are the sum of fixed and variable costs, and variable costs c(Q).

$$\pi(p) = p \cdot Q(p) - c(Q(p)) - F > 0, \text{ where}$$

$$\pi_p = Q + (p - c_Q)\, Q_p.$$

Since consumers prefer lower prices, all prices considered by the regulator lie below the profit maximizing price, so $\pi_p > 0$. Demographic characteristics affect demand and costs. The extent to which profit translates into industry votes, NV^S_{π}, is assumed to depend on factors such as competition, lobbying, campaign contributions, corporate strategy, and industry size. Stated formally, the regulator's problem [RP] is to choose price to maximize net votes:

$$\max_{p} \ NV, \quad \text{where } NV = NV^S + NV^C. \qquad \text{[RP]}$$

At a maximum of [RP], the following two conditions must hold:

$$\begin{aligned} \frac{dNV}{dp} = 0 &= NV_p^S + NV_p^C \\ &= \pi_p \cdot NV_\pi^S - Q \cdot NV_{CS}^C, \text{ and} \end{aligned} \qquad (2.5)$$

$$\frac{d^2NV}{dp^2} = \pi_{pp} \cdot NV_\pi^S - Q_p \cdot NV_{CS}^C < 0. \qquad (2.6)$$

In equation (2.5), NV^S_p and NV^C_p, respectively, capture the voting responsiveness of each group to small price changes. At the maximum level of net votes, price is such that the marginal gain in supplier votes from a higher price equals the marginal loss of consumer votes: $\pi_p \cdot NV_\pi^S = Q \cdot NV_{CS}^C$. As Figure 2.1 depicts, the equilibrium price and quantity (p^*, q^*) occur where the consumer and supplier voting responsiveness curves intersect. At the profit-maximizing quantity, q^{mnply}, $NV^S_p = 0$, so in equilibrium $q^* > q^{mnply}$ and $p^* < p^{mnply}$. The figures reflect the simplifying assumptions that suppliers have sufficiently concentrated interests that $q^* < q^{comp}$, and NV^S_p, NV^C_p, and demand are all linear.

Comparative Statics

The relative positions of the consumer and industry voting responsiveness curves determine the equilibrium price and quantity. As was suggested earlier, demographic considerations of the state population and industry determine the extent to which marginal changes in price translate into votes.

Characteristics that impact consumer voting responsiveness

Consumer voting support decreases as price increases:

$$NV^C_p = - Q \cdot NV^C_{CS} < 0 \quad \text{for all } Q > 0. \tag{2.7}$$

Clearly, the number of consumer votes lost as price increases becomes greater as consumers purchase more (i.e., Q is greater). When Q is larger or if voters are more sensitive to changes in consumer surplus (i.e., NV^C_{CS} is greater), more net votes are at stake through a small price change (i.e., NV^C_p is greater). Let the population characteristic "e" be defined so that consumer voting responsiveness to changes in consumer surplus rises as e increases. That is,

$$NV^C_{CS,e} > 0, \text{ so} \tag{2.8}$$

$$|NV^C_{p,e}| > 0. \tag{2.9}$$

Graphically, Figure 2.2 depicts the effect of an increase in consumer voting responsiveness. As a higher percentage of the consumer population changes their votes in response to price changes for any given level of output, shown as an increase in $|NV^C_p|$, a greater quantity and lower price result in equilibrium, *ceteris paribus*. Examples of measurable factors that may increase the effect of price changes upon consumer voting are

- Income,
- Partisanship of state administration,
- Elected or appointed regulators, and
- Rent-seeking.

Since individuals with a high value of time, other things equal, find it costlier to acquire political information, their income should be less sensitive to price changes. Suppose, for example, that the marginal impact of an increase in consumer surplus upon net votes from consumers, NV^{C}_{CS}, is inversely proportional to wage rates. Suppose also that wage rates are linear in income. Then

$$NV^{C}_{CS} = \beta\left(\frac{1}{\text{INCOME}}\right). \tag{2.10}$$

The (absolute value) change in net consumer votes as price rises is then

$$\left|NV^{C}_{P}\right| = Q\left(\frac{\beta}{\text{INCOME}}\right). \tag{2.11}$$

Estimates for the Bell system suggest that the demand for intrastate long-distance calls is predominantly income elastic in the long-run.[15] If so, consumption of intraLATA toll services (Q) increases more rapidly than income. Consumers in high income states therefore are predicted to be more sensitive to price changes, raising $|NV^{C}_{p}|$ and resulting in lower prices.

In the Stigler and Peltzman models, the regulator is nonpartisan and maximizes a voting majority. In practice, partisanship and whether the regulator is elected or appointed may be integral parts of the regulator's maximization.[16] For example, as price increases, consumers are less likely to vote for an elected regulator. When consumers are voting for a governor or legislator that appoints regulatory commissioners, the vote is based upon a broader set of criteria, so the impact of price upon net votes, $|NV^{C}_{p}|$, is smaller. Thus, price is expected to be higher in states with appointed regulators.

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[15] For intrastate toll, L. Taylor (1994, Table 1, p. 318-319) cites studies of states within the Bell System. The majority of long-run income elasticity estimates exceeds one, and the average is 1.33 (over the 27 states for which long-run elasticity estimates are reported).

[16] Regulatory commissioners are elected in AL, AZ, GA, LA, MS, MT, NE, NM, ND, OK, SD, and TN. All other states appoint regulatory commissioners.

Partisanship may also impact the state regulatory process. The Republican party often espouses the interests of wealthier constituents. When demand is income elastic, wealthier consumers, who are represented by the Republican party, spend a greater portion of their income on intraLATA toll calls and thus have more to gain from lower prices. Wealthier citizens are also expected to be more active politically or more represented in states where government is controlled by the Republican party. Consistent with the prediction on INCOME, consumer voting responsiveness to toll rates, $|NV^C{}_p|$, should be largest in states under Republican leadership and result in a lower equilibrium price.

If a state allows more rent-seeking--access by special interests (suppliers)--campaign contributions may enable the regulator or legislator (if regulator is appointed) to provide more information via advertising. Accentuating accomplishments through advertising may defray the loss of consumer votes as price rises. With a lower $|NV^C{}_p|$, equilibrium price will increase and quantity decrease with rent-seeking.

Characteristics that impact supplier voting responsiveness

A small price increase generates additional supplier votes given by

$$NV^S{}_p = NV^S{}_\pi \cdot \pi_p > 0. \tag{2.12}$$

The impact price has upon profit, and thereby voting, depends upon demand, costs, and the impact of profit upon net votes by suppliers, $NV^S{}_\pi$.

In addition to decreasing $|NV^C{}_p|$, rent-seeking may also increase $NV^S{}_\pi$. Greater lobbying and campaign contributions reflect greater organization among suppliers, so more supplier votes are at stake for any given output level. The supplier voting responsiveness curve, NV^S_p, becomes steeper beginning at q^{mnply}, as shown in Figure 2.3. In conjunction with lower $|NV^C_p|$, an increase in NV^S_p increases the amount by which equilibrium price rises and quantity falls with rent-seeking.

Threats of entry and the presence of large industrial consumers are examples of factors that affect demand. The presence of large corporate consumers results in a larger Q(p) and $|NV^C_p|$: the effect depicted in Figure 2.2. With greater incentives to bypass the local network, large corporate consumers typically have more elastic demand. Threats of entry may also induce more elastic demand. As demand becomes more elastic, the profit-maximizing output increases. There is less additional profit earned by restricting output; this leads to a decrease (rightward shift) in NV^S_p as shown in Figure 2.4. The equilibrium quantity rises and price falls. Therefore, more elastic demand attributable to threats of entry or the presence of large industrial consumers leads to lower prices.

Production costs also affect industry voting. Consider Figure 2.5, which depicts a decrease in the marginal costs. For the same technology, suppliers in one state might enjoy lower costs due to regional cost-of-living and wage differences. Network maintenance may also cost less in regions with temperate climates.[17] With lower marginal cost, the profit-maximizing output increases. Suppliers earn less additional profit by restricting output to the former profit-maximizing level, so their voting responsiveness curve (NV^S_p) shifts rightward and a lower equilibrium price results. Thus, states where labor or maintenance costs are lower should have lower prices.

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[17] For example, NYNEX's 1993 operating expenses rose 1.6% mainly because of higher depreciation expenses and network repair costs associated with severe winter storms (FCC 1994).

2.3. The Empirical Analysis

The foregoing model of state price regulation suggests that those characteristics that drive consumer and supplier voting behavior also determine relative prices across states. IntraLATA toll prices are used to test the predictions of the model.

Specification Issues and Estimation Procedure

The first issue of econometric specification is whether intraLATA toll rates are jointly dependent with other telecommunications prices and part of a simultaneous equations system. Simultaneous determination of local and toll rates may be important in examining specific policies, such the relationship between universal service and cross-subsidization.[18] The goal here is to identify more general characteristics that affect intraLATA toll rates. Accepting interrelation among local service rates, toll rates, and access charges, the crux of the issue is whether it is appropriate to attempt to explain intraLATA toll prices using other prices. The problem is that all prices might be explained by the same underlying factors, and these factors are what drive the rate differences among states.[19] That is, it is difficult to plausibly argue that a factor affects one price but not other prices. For this reason, a reduced form is utilized here.

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[18] Kaestner and Kahn (1992) approach the intraLATA toll market by including separate equations for local, toll, and access prices. Kaserman et al. (1990) use a simultaneous equations model to examine the impact of cross-subsidization between local and toll upon telephone subscription rates. Im et al. argue for simultaneity in their study of electric utility regulation.

[19] Atkinson and Nowell (1994) argue for a reduced form (against a simultaneous approach) on different grounds. They analyze regulatory commission behavior as it relates to the use of regulatory lag as a policy tool in the electric power industry. They argue that identification problems stem from inadequacy of existing "theory of regulatory bargaining" to provide a "set of potential instruments" (p. 636).

The second specification issue regards the estimation procedure via the type of sample, cross-section or panel. In comparison to cross-sectional data, panel data increases the degrees of freedom, reduces collinearity among explanatory variables, and permits the study of policy changes over time. The time dimension is especially useful for estimating the effects of actual or potential competition, which has increased over time. The sample chosen here is a panel that covers the 48 contiguous United States over years 1983, 1986, 1988, 1990, and 1992.[20] The initial year, 1983, provides a pre-divestiture benchmark.

To explain intraLATA toll prices ($PRICE_{it}$), three reduced form equations consistent with the foregoing model are estimated. The subscripts denote the specific state (i) at a point in time (t). Since decisions to allow intraLATA toll competition and interconnection--competitor access to parts of the incumbent BOC's local network--are endogenous with the price level, Model 1 presents results without variables related to these decisions. Models 2 and 3 add to Model 1 variables that measure competition and interconnection in slightly different ways. Table 2.1 provides brief definitions and descriptive statistics for each of the variables. The reduced form models considered here are

Model 1:
$$\begin{aligned} PRICE_{it} = {} & \beta_0 + \beta_1\, APPOINT + \beta_2\, CABLEPEN + \beta_3\, CABLEREG \\ & + \beta_4\, FORT500 + \beta_5\, INCOME + \beta_6\, JANUARY \\ & + \beta_7\, JULY + \beta_8\, JULY^2 + \beta_9\, LOBBY + \beta_{10}\, REPUBLICAN + u_{it} \end{aligned}$$

Model 2:
$$+ \beta_{11}\, COMPACC + \beta_{12}\, INTRACOMP + \beta_{13}\, INTRACOMP*FORT500$$

Model 3:
$$+ \beta_{11}\, COMPACC + \beta_{12}\, INTRACOMP + \beta_{13}\, COMPACC*FORT500.$$

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[20] Adding odd years gives little additional variation to the sample.

The coefficients to be estimated are β_0-β_{13}. The analysis finds a variance components error structure (random effects model) is appropriate.[21] There are a total of N cross-sections and T time series. The random error associated with $PRICE_{it}$, u_{it}, is assumed the sum of the random effects associated with the *i*th cross-section (v_i), the *t*th time series (e_t), and both cross-sections and time series (ε_{it}):

$$u_{it} = v_i + e_t + \varepsilon_{it}, \quad i = 1,..,N; \; t = 1,...,T.$$

The v_i are assumed constant over time, and the e_t are assumed constant across cross-sections. The errors v_i, e_t, and ε_{it} are independently distributed with zero means and variances $\sigma_v^2 \geq 0$, $\sigma_e^2 \geq 0$, and $\sigma_\varepsilon^2 \geq 0$, respectively. The variance components are estimated using the two-step Generalized Least Squares (GLS) procedure developed by Fuller and Battese (1974).[22] Advantages of this procedure are its ability to incorporate variables that are constant over time or over cross-sections as well as its robustness to the underlying error structure.[23]

The dependent variable ($PRICE_{it}$) equals the real price charged by the BOCs operating in each state.[24] Only one BOC operates in each state, and the BOCs account for the vast majority of intraLATA toll calls. In addition, by focusing upon the rates of BOCs, quality of service remains relatively constant across states. Call prices may vary by time of day, duration (in minutes), and distance (mileage). Calls that fall into more distant mileage bands generally bear higher prices. Following Mathios and Rogers (1990), call prices are calculated for each of the eight bands used by most states: 0-10 miles, 11-16 miles, 17-22 miles, 23-30 miles, 31-40 miles, 41-55 miles, 56-70 miles, and 71-124 miles.[25,26] For a standardized comparison across states, the dependent variable measures the price of a five minute, day-time intraLATA telephone call in a specified mileage band. Since there are eight mileage bands, there are eight price observations per state for each year.

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[21] Since variance components estimates are inconsistent when the individual intercepts v_i are correlated with the independent variables (Greene 1993, p. 495), the Hausman test statistic for the difference between the fixed effects and random effects estimates has been checked to verify noncorrelation. The statistic does not reject the null hypothesis of noncorrelation, so a random effects procedure is appropriate.

[22] When the effects for individuals are assumed random, the best linear unbiased estimator (BLUE) is the generalized least squares estimator (Hsaio 1986, p. 34).

[23] When the sample size is large, the two-step GLS estimator has the same asymptotic efficiency as the GLS procedure with known variance components (Fuller and Battese 1974, Hsiao 1986).

[24] The one exception is the inclusion of Southern New England Telephone, the primary local exchange carrier (LEC) in Connecticut.

Dummy variables capture the effect of distance on price. Following the structure of Mathios and Rogers (1990), a "pooling model" is employed where all mileage ranges for a given year are analyzed together in a single equation.[27] To adjust for potential correlation among error terms across different observations, the regressions also include dummy variables that capture the effects of company specific variations and time-specific variations. The omitted dummy variable from each set is indicated in Table 2.1.

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[25] Mathios and Rogers (1990) note that some states have mileage bands that exceed 124 miles, while others charge a fixed rate for calls beyond a certain distance. Since some states are not large enough to yield meaningful comparisons for distances longer than 124 miles, call prices above 124 miles are not used in this study.

[26] For example, if a state charges one rate per minute for a call that spans up to eight miles and a different rate for a call that covers greater than eight miles, the standardized rate for the 0-10 mileage band is calculated simply as 0.8 times the short distance rate plus 0.2 times the rate for the longer distance.

[27] As Mathios and Rogers (1990) note, a separate reduced form equation could be estimated for each mileage band. Since omitted variables likely affect all mileage bands, this approach may be inconsistent.

Explanatory Variables and Hypotheses

Measures of consumer voting responsiveness to price

Categories of explanatory variables the foregoing model predicts impact consumer voting and, thereby, the equilibrium price are

- Income,
- Partisanship of state administration,
- Elected or appointed regulators, and
- Rent-seeking.

As a proxy for consumer income, real personal income per capita (INCOME) is included (1983-1992).[28] As was discussed, the predicted sign of the coefficient on INCOME is negative. The effect of income should be consistent with that of Republican control of the state administration. The variable REPUBLICAN measures whether one political party controls both the governor's seat and a majority in the state legislature (1983-1992), and the predicted sign on the coefficient for REPUBLICAN is negative.[29] The variable APPOINT indicates whether state regulatory commission members are appointed or elected; this variable remains constant over 1983-1992.[30] The sign of the coefficient on APPOINT should be positive. As a proxy for rent-seeking, LOBBY measures the number of lobbyists per state legislator in 1992.[31] These data do not measure only those lobbyists representing the telecommunications industry but still reflect the degree of rent-seeking in the state. Effective lobbying should lead to higher prices than would prevail otherwise, so the predicted sign of the coefficient on LOBBY is positive.

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[28] Real personal income per capita is calculated as current dollar personal income per capita adjusted by the consumer price index. All figures are from the U.S. Department of Commerce (1993).

[29] REPUBLICAN equals one for Republican party control, negative one for Democratic party control, and zero otherwise. Data on party control of governor's seat and state legislature were obtained from Husted and Kenny (1994).

[30] Source of data on whether utility commissioners are elected or appointed: NARUC (1992).

[31] Source of data on state lobbyists: Morgan et al. (1993).

Measures of supplier voting responsiveness to price

Three main categories of variables identified in the model that affect supplier voting are

- Presence of large industrial consumers,
- Threats of entry, and
- Regional cost differences (shifts in cost function).

As a proxy for the presence of large industrial consumers, FORT500 contains the total number of "service" and "industrial" Fortune 500 firms--a total of 1000 firms--with headquarters located in the state (1983-1992).[32] The model predicts that a greater presence by large industrial consumers corresponds to lower rates, so the predicted sign on the coefficient for FORT500 is negative. In the theoretical model, competitive entry is associated with a greater demand elasticity. As a measure of state policy, Models 2 and 3 include the variable INTRACOMP, which equals one if a state currently allows facilities-based intraLATA toll competition and equals negative one otherwise.[33,34] The predicted coefficient sign on INTRACOMP is negative. In itself, statutory allowance of intraLATA toll competition may not attract competitive entry. Model 2 includes an interaction of INTRACOMP with the number of Fortune service and induatrial 500 headquarters located in state (INTRACOMP*FORT500). The interaction with the number of Fortune 500 headquarters creates a proxy of where competition is both allowed and more likely to occur. The coefficient sign for the interaction should also be negative.

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[32] Source of data on Fortune 500 headquarters locations: *Fortune* (1985-1992).

[33] Source of data on intraLATA toll competition by state: NARUC (1983-1992).

[34] By 1992, only three of 48 states in the sample prohibit resale competition: AZ, IN, and RI (NARUC, 1992-1993, Table 170). For this reason, attention is restricted to facilities-based competition.

Threats of entry may represent actual or potential competition. Cable television stands as a viable future competitor for telecommunications services, especially in the markets for video dial tone and local service.[35] CABLEREG measures whether the state regulatory commission (as opposed to the legislature or an independent agency) holds authority over the entry of cable television (1=yes, -1=no); this variable remains constant over time.[36] The predicted coefficient sign on CABLEREG is negative. A counterpart to the authority measure is the actual presence of cable television, as measured by cable penetration rates. CABLEPEN contains the number of cable households as a fraction of the total number of television households in the state (1983-1992).[37] As an entry threat, cable penetration may lead to lower rates. Historically, cable penetration is also highest in suburban areas where television reception is poor and any competitive entry would be less likely. If the former effect dominates, CABLEPEN will be inversely related to prices.

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[35] Cable and telephone may become allies or competitors. For example, in California, approximately 40% of the 8.4 million homes that subscribe to cable are served by carriers that recently announced affiliations with Bell companies (Quigley, 1994b). By contrast, in New York state, Cablevision Lightpath Inc. is investing $300 million in the "nation's largest electronic highway" and (through an arrangement with AT&T) is offering "integrated cable, local telephone, and long-distance services to large users such as college campuses" (Seidenberg, 1994).

[36] Seven commissions have authority over cable television entry. Source of data on state PUC authority over cable entry: NARUC (1993c).

[37] Sources of data on cable penetration rates: A.C. Neilsen Co. (1987-1992) and U.S. Department of Commerce (1991).

Another entry threat stems from competitive access providers. Competitive access providers already compete against BOCs and each other primarily in the markets for high-volume access, delivering traffic from large customers directly to interexchange carriers.[38] Competitive access providers have also begun to compete as alternative local exchange carriers.[39] COMPACC measures the penetration rate of competitive access providers as the percentage of the state population living in urban areas actually served by competitive access providers in 1992.[40] This variable contains a single cross-section that is also a proxy for the location of high-volume consumers, potential scale economies in the firm's cost structure, and the most profitable areas to serve.[41,42] An alternative variable that directly measures the lines of competitive access providers (as a percentage of total or BOC lines in the state) would be problematic: first, a meaningful comparison requires data on lines of comparable capacity; second, many competitive access providers' lines have high-speed transfer rates not always available from the BOCs. The predicted coefficient sign for COMPACC is negative. Model 3 also includes an interaction of COMPACC with the number of Fortune 500 headquarters in the state:

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[38] For example, 30% of Pacific Bell's business revenues come from 0.5% of their serving territory. Quigley (1994) estimates that competitive access providers hold a 25-33% share of the high-capacity market in the Los Angeles and San Francisco areas they serve.

[39] Huber (1992) cites that competitive access provider "TCI claims that it is now the largest single buyer of fiber-optic cable in the world" (p. 2.59). Huber (1992) also contains an excellent discussion of the strategic presence of both competitive access providers and cable carriers.

[40] Sources for data on competitive access providers and urbanized populations: Huber et al. (1992), U.S. Dept. of Commerce (1990a) and (1992), Slater et al. (1994).

[41] Regressions with COMPACC as the dependent variable have an R-square of 0.60 using urbanization, population density, access revenue per minute, and the number of Fortune 500 headquarters in the state as the only explanatory variables.

[42] See the *State Telephone Regulation Report* (1994) for three recent articles on CAP location patterns.

COMPACC*FORT500. If penetration by competitive access providers results in significantly lower toll rates in states with more large industrial consumers, the predicted coefficient sign on the interaction is negative.

While materials costs (e.g., fiber, switches, computers, etc.) should be comparable among BOCs, wages due to differences in the cost of living and amenities vary by region.[43] As a measure of the cost-of-living, amenities in labor markets, and of comparative network maintenance expenses across states, consider the relationship between wages and average temperatures (JANUARY, JULY).[44] Since living costs are lower and the climate more attractive, less compensation is necessary for a worker as January temperatures rise. In July, by contrast, extremely hot or cold temperatures require greater compensation. Beginning at a cold July temperature, warmer temperatures decrease the required wage. Beyond a certain point, hotter July temperatures require greater compensation at an increasing rate. Aggarwal and Kenny (1994) and Kenny and Denslow (1980) find wages are lowest with July temperatures of 74°-82°. Figure 2.6 depicts these relationships. Additionally, network maintenance costs may be higher in extreme climates. For example, costs may be higher in states with cold January climates and winter storms (e.g., New York, Illinois, New England states) or states with hot July temperatures and notable lightning storms or hurricane seasons (e.g., Florida, Mississippi, Texas, Louisiana). Therefore, the predicted coefficient sign should be negative for

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[43] One difficulty with directly measuring average wages for telecommunications workers is that telephone companies hire workers with vastly different human capital levels.

[44] Aggarwal and Kenny (1994) and Kenny and Denslow (1980) both find significant relationships between wage levels and average temperatures in January and July. Data on average temperatures were obtained from Kenny.

January temperatures, negative for July temperatures, and positive for the square of July temperatures.

2.4. Estimation Results

Tables 2.2, 2.3, and 2.4 present results from OLS and the two-step GLS (random effects) procedure for Models 1-3, respectively. Based on the two-step GLS estimation, Table 2.5 presents estimates of the impact the explanatory variables have on the price of a five-minute intraLATA call. Overall, Models 1-3 perform well. The R-squares for OLS regressions are all approximately 0.78.[45] The explanatory variables also perform well and suggest that intraLATA toll rates are lower in states where consumers are more sensitive to higher rates. The OLS regressions provide highly significant t-statistics that almost always exceed those from the two-step GLS procedures. The following discussion focuses on the results of the random effects procedures. Since the mean price is $1.00, the coefficients give the fractional response.

Results on Measures of Consumer Voting Responsiveness

The measures of income and partisanship perform as predicted. In all regressions, the coefficient on the measure of real personal income per capita (INCOME) is significant with the predicted negative sign at the .01% level (two-tailed test); this result is robust to the presence of any and all other explanatory variables.[46] Republican party control of the governor's seat and a state legislature majority (REPUBLICAN) is also significant in all regressions with the predicted negative coefficient sign at the 10% level (single-tailed test). Both results are consistent evidence that demand for intraLATA toll calls is income elastic in the long-run. When demand is income elastic, wealthier consumers, who are represented by the Republican party, spend a greater portion of their income on intraLATA toll calls and thus have more to gain from lower prices. Wealthier citizens are also expected to be more active politically or more represented in states where government is controlled by the Republican party. Thus, under income elastic demand in the long-run, the model predicts lower prices with greater income and Republican control. In states where personal income per capita is $2134 higher (one standard deviation), toll rates are 21.3% lower. Similarly, states with Republican party control of the governor's seat and the state legislature have toll rates that are 4% lower than states controlled by Democrats.

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[45] Orthoganality conditions prevent calculation of R-square statistics with two-step GLS.

[46] The coefficient sign on income differs from the finding of Mathios and Rogers (1990); their result corresponds to income inelastic demand but may be an artifact of cross-sectional analysis. For

Rent-seeking and whether regulatory commissioners are appointed or elected also play significant roles in determining rate differences among states. The measure of rent-seeking, LOBBY, is significant at the 8% and 9% levels in Models 2 and 3 only. If a state allows more rent-seeking, campaign contributions may enable the regulator or legislator (if regulator is appointed) to spend resources to defray the potential loss of consumer votes as prices rise. IntraLATA toll rates are 1.6%-2% higher in states with about six additional lobbyists per legislator.

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example, L. Taylor (1994, pp. 326-327) cites Stuntebeck (1976) who finds income inelastic demand when looking at a cross-section sample but finds income elastic demand in a pooled sample.

As prices increase, consumers are less likely to vote for an elected regulator. When consumers are voting for a governor or legislator who appoints regulatory commissioners, the vote is based upon a broader set of criteria, so the impact of an increase in intraLATA toll rates upon net votes by consumers is smaller. As predicted, APPOINT is significant at the 4%-7% levels (single-tailed tests) in Models 1-3, and states with appointed regulators are found to have intraLATA toll rates that are 4%-5% higher.

Results on Measures of Supplier Voting Responsiveness

Average January and July temperatures have significantly negative effects upon toll rates. JANUARY is significant at the 4% level (single-tailed test) in Model 1, and narrowly misses 10% significance in Models 2 and 3. July temperatures (JULY) and the square of July temperatures ($JULY^2$) are significant with the predicted signs at the 5% level in Models 1 and 2 and at the 10% level in Model 3. These results reflect that wages due to differences in the cost of living and amenities vary by region, and network maintenance expenses may be lower in states with less extreme climates. In states where the temperature is 13° warmer on average in January, toll rates are 2%-3% lower. By comparison, the lowest toll rates occur in states where July temperatures are about 80°. This is consistent with the range of 74°-82° found in Aggarwal and Kenny (1994) and Kenny and Denslow (1980). Extreme temperatures in either direction away from 80° correspond to progressively higher toll rates. Beginning at 80°, states where average July temperatures are about five degrees warmer or cooler (one standard deviation) have toll rates that are roughly 1%-1.5% higher. The finding here that extreme January temperatures have a larger impact upon toll rates than July temperatures is also consistent with the finding of Kenny and Denslow (1980) that January temperatures correspond to larger wage differentials than do July temperatures.

The most direct measure of potential competition in the intraLATA toll market, statutory allowance of facilities-based intraLATA toll competition, produces the weakest results. Models 2 and 3 include the status of competition in the state, INTRACOMP. Model 2 also includes the interaction of the competition status with the number of Fortune 500 headquarters located in the state (INTRACOMP*FORT500). Statutory allowance of facilities-based intraLATA toll competition and its interaction with FORT500 have the predicted negative coefficient signs, but neither is significant. Lack of support for the hypothesis that statutory allowance of intraLATA toll competition leads to lower rates is consistent with the findings of Kaestner and Kahn (1992), the only other study of intraLATA toll that examines intraLATA toll rates over multiple years. An explanation for these results may be that the absence of 1+ dialing parity in intraLATA toll competition has prevented competitors (primarily interexchange carriers) from making substantial inroads into the market.

In contrast to the weak results on the status of intraLATA toll competition, threats of entry from cable television and competitive access providers have larger impacts. Cable providers, who are well positioned through consortia with competitive access providers, cellular providers, and PCS radio services (Huber, 1992, p. 2.63), may be perceived as greater threats when the state regulatory commission has authority over cable entry. State commissions with authority over cable television also may have a broader scope of total authority. The authority measure, CABLEREG, is significant at the 0.2% level (single-tail test) in all regressions and corresponds to toll rates that are between 10% and 18% lower, or about \$0.10 to \$0.18 on an average-distance, five-minute call. In contrast to the authority measure, cable penetration rates (CABLEPEN) are not significant; this is not surprising since, as discussed, cable penetration rates entail the aforementioned offsetting effects.

States where competitive access providers are more active also have significantly lower intraLATA toll rates. COMPACC measures the penetration rate of competitive access providers in 1992 and is significant at the 7% and 10% levels in Models 2 and 3, respectively (single-tailed test). Toll rates are estimated to be 3.3% lower when competitive access providers serve urban areas that constitute an additional 23% of the state population in Model 2. Model 3 interacts competitive access provider penetration rates with the number of Fortune 500 headquarters located in the state (COMPACC*FORT500); the interaction is also significant with a negative coefficient at the 0.2% level (single-tailed test). The relationship described by the interaction is estimated in Model 3 as

$$\frac{\mathrm{dp}}{\mathrm{d\ COMPACC}} = -0.1211 - 0.007\ \mathrm{FORT500}\,.$$

As expected, the negative impact of additional competitive access providers upon rates is more pronounced in states where there are more large industrial consumers. At the mean of about 21 Fortune 500 headquarters in a state, toll rates are estimated to be 6.1% lower in states where competitive access providers serve urban areas that constitute an additional 23% of the state population. When there are about 49 Fortune 500 headquarters in a state (one standard deviation from mean), the same 23% increase in competitive access provider penetration corresponds to toll rates that are an estimated 10.75% lower.

Similarly, an increase in the number of Fortune 500 headquarters through the interaction is estimated as

$$\frac{dp}{d\,\mathrm{FORT500}} = 0.0029 - 0.007\ \mathrm{COMPACC}\,,$$

which is negative only when competitive access provider penetration exceeds 41%. This result suggests that the presence of additional Fortune 500 firms has the largest negative impact upon intraLATA toll rates when competitive access providers have a greater presence in the state. Intuitively, large industrial consumers have strong incentives to bypass the network, and competitive access providers offer a means of bypass. Without any interaction, FORT500 has a significantly negative impact (at the 2% level for a single-tailed test) upon intraLATA toll rates in Model 1. At the mean of about 21 headquarters, an additional 29 Fortune 500 headquarters located in the state (one standard deviation) corresponds to toll rates that are 5.2% lower.

In comparison of the results on intraLATA toll competition and threats of entry, it appears that BOC intraLATA toll prices are lower in response to the long-term consequences of potential entry from competitive access providers and convergence with cable. To see why this might be the case, consider the fact that the largest current competitors in intraLATA toll are interexchange carriers (IXCs). Even with eventual 1+ dialing competition, the most IXCs alone can capture is a (substantial) share of the intraLATA toll market. By contrast, the entry of competitive access providers, cable, and consortia of these two with interexchange carriers poses a formidable threat to the BOC's total revenue stream. Market share lost to these competitors may take with it the revenues presently earned from toll, basic local service, and access.

Results of Dummy Variables

The regressions include three sets of dummy variables to capture the effects of the distance sensitivity of prices, company specific variations, and time-specific variations. The estimated coefficients for the dummy variables on the different mileage bands are all significant at the 0.01% level. Since prices increase with distance, the negative coefficients on each of the remaining mileage bands represent the percentages by which the mean price for the band is lower than that for the 71-124 miles band. For example, the price for a five-minute day-time call in the 56-70 miles band is approximately 9.4% lower than a call in the 71-124 miles band. A call in the 0-10 miles band is approximately 97% less expensive than one in the 71-124 miles band.

Similarly, dummy variables for each year indicate that prices between 1983 and 1988 were significantly (at the .01% level) higher in real terms than those in 1992. Between 1983 and 1988, the price of a five-minute call declined approximately 5% annually. In 1990, however, the downward price trend halted. The insignificant dummy variable for 1990 suggests that 1992 prices are approximately one percent higher than those in 1990.

Finally, the dummy variables for each company (AMERITECH, . . . ,USWEST) are all significant at the 2% level (single-tailed test). The estimated coefficients on the company-specific dummy variables are all relative to the excluded company, Southern

New England Telephone. Relative to Connecticut and controlling for other differences, US West states have by far the lowest toll rates: roughly 36%-56% lower.[47] After US West, Ameritech and Southwestern Bell states have the next lowest toll rates, roughly 23%-39% lower than those in Connecticut, BellSouth, Pacific Bell, and NYNEX follow last with rates that are up to 20% lower than those in Connecticut.

2.5. Conclusions

This research has developed and tested a stylized model of price setting in a state regulatory environment. The empirical investigation of intraLATA toll prices (1983-1992) finds that state statutory allowance of facilities-based intraLATA toll competition is not a major force that drives toll prices lower, even when the market size is taken into consideration; this result might be explained by the absence of 1+ intraLATA toll dialing parity. A number of results suggest that intraLATA toll rates are lower in states where consumers votes are more sensitive to price. In particular, intraLATA toll rates are found to be significantly lower in states with (1) elected regulatory commissioners, (2) Republican control of both the governor's seat and a majority in the state legislature, (3) higher personal income per capita, (4) less rent-seeking in the state legislature, (5) lower costs of living and more temperate climates, and (6) more large industrial consumers. Additionally, the analysis finds evidence that toll rates are significantly lower in states where threats of entry from competitive access providers and cable television are larger;

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[47] These findings are suggestive of those in Teske (1991b), who addresses how US West "correctly perceived that the political environment in which they operated differed greatly from that in the rest of the country and that a deregulatory strategy was appropriate" (p. 235). It is not obvious, however, why deregulation encouraged by US West need result in lower toll rates.

entry by these competitors may take with it the revenues earned in the markets for toll, basic local service, and access.

This investigation opens the door to numerous directions of future research. A promising direction for analysis is a detailed study of comparative performance by elected and appointed commissioners. Findings here suggest that intraLATA toll rates are 4%-5% lower in states with elected regulators. If elected regulators are more sensitive to constituents' concern for prices, an important question is whether these same states have experienced lower quality or slower adoption of new technologies. With data on rent-seeking specifically by regulated industries, it would be interesting also to examine whether rent-seeking is significantly greater in states with appointed or elected regulatory commissioners.

Another direction for research is a detailed analysis of the relationship between state commission authority and regulatory policy. More specifically, among state commissions of comparable size and budgetary resources, it would be insightful to know what factors most contribute to lower rates, e.g., scope of authority, stringency in monitoring (auditing), choice of regulatory techniques and policies.

The significant findings on threats of entry suggest the need for a more detailed examination of the respective roles of cable and competitive access providers. Pooled data on the growth of competitive access providers would be useful, and the measurable impact of competitive access providers should become even stronger with expanded interconnection in the future. With data that provide greater industry detail, including technology measures, it should be possible to gain more insight into the relationships among prices, costs , threats of entry, and where interconnection with local exchange carriers occurs. Other factors external to this model, such as changes in regulatory regimes or reductions in Federal access charges (that are passed through to the state level nd reflected through lower intraLATA access charges) also deserve attention.[48] -

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[48] Donald and Sappington (1994) examine determinants of state adoption of incentive regulation. Greenstein et al. (1994) focus on the impact of incentive regulation upon technological deployment.

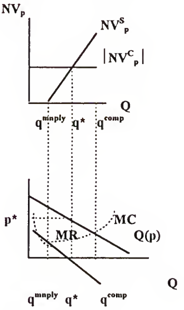

FIGURE 2.1. Equilibrium

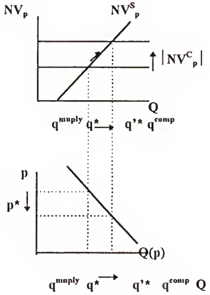

FIGURE 2.2. Increase in $|NV^C_p|$

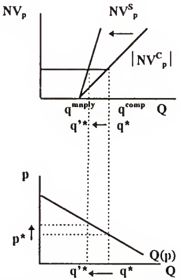

FIGURE 2.3. Increase in NV^S_π

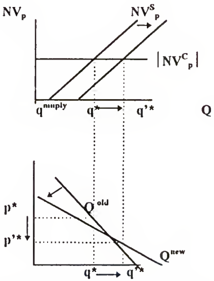

FIGURE 2.4. Increase in Demand Elasticity

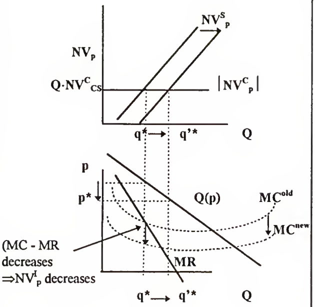

FIGURE 2.5. Lower marginal costs

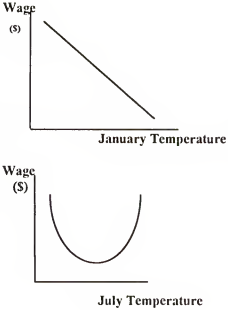

FIGURE 2.6. Wages and average seasonal temperatures

Table 2.1. Variables Used To Explain IntraLATA Toll Rates

Variable	Definition	Mean	Std. Dev.
APPOINT	=1 if regulators appointed, =-1 otherwise	0.50	0.87
CABLEPEN	Cable penetration rate as fraction of television households	0.51	0.12
CABLEREG	=1 if PUC has authority over CATV entry, =-1 otherwise	-0.75	0.66
COMPACC	Competitive access provider penetration rate (1992)	0.20	0.23
COMPACC*FORT500	Interaction of CAP penetration rate with Fortune 500 HQs	8.40	17.95
FORT500	Number of Fortune 500 headquarters in state	20.53	28.67
INCOME	Real personal income per capita ($)	12937	2134
INTRACOMP	= 1 if state permits facilities-based intraLATA toll competiton, =-1 otherwise	0.00	1.00
INTRACOMP*FORT500	Interaction intraLATA toll competition status with Fortune 500 HQs	2.22	35.20
JANUARY	Average January temperature for state	27.17	13.00
JULY	Average July temperature for state	75.48	5.15
JULY2	Square of average July temperature for state	5723	798
LOBBY	Number of lobbyists per legislator (1991)	6.04	5.47
PRICE	Real price of intraLATA long-distance call ($)	1.00	0.44
REPUBLICAN	= 1 if Republican governor and majority state legislature = 0 if parties (D/R) split governor and majority state legislature. =-1 if Democratic governor and majority state legislature	-0.23	0.61
AMERITECH	=1 if state is part of Ameritech, =0 otherwise	0.10	0.31
BELLAT	=1 if state is part of Bell Atlantic, =0 otherwise	0.13	0.33
BELLSTH	=1 if state is part of BellSouth, =0 otherwise	0.19	0.39
NYNEX	=1 if state is part of NYNEX, =0 otherwise	0.13	0.33
PACTEL	=1 if state is part of Pacific-Telesis, =0 otherwise	0.04	0.20
SWBELL	=1 if state is part of Southwestern Bell, =0 otherwise	0.10	0.31
USWEST	=1 if state is part of U.S. West, =0 otherwise	0.29	0.45
SNET-DROP*	=1 if state is CT, =0 otherwise	0.02	0.14
0 -10 MI	=1 if call is between 0 and 10 miles, =0 otherwise	0.13	0.33
11-16 MI	=1 if call is between 11 and 16 miles, =0 otherwise	0.13	0.33
17-22 MI	=1 if call is between 17 and 22 miles, = 0 otherwise	0.13	0.33
23-30 MI	=1 if call is between 23 and 30 miles, =0 otherwise	0.13	0.33
31-40 MI	=1 if call is between 31 and 40 miles, =0 otherwise	0.13	0.33
41-55 MI	=1 if call is between 41 and 55 miles, =0 otherwise	0.13	0.33
56-70 MI	=1 if call is between 56 and 70 miles, =0 otherwise	0.13	0.33
71-124 MI-DROP*	=1 if call is between 71 and 124 miles, =0 otherwise	0.13	0.33
1983	=1 if year is 1983, =0 otherwise	0.20	0.40
1986	=1 if year is 1986, =0 otherwise	0.20	0.40
1988	=1 if year is 1988, =0 otherwise	0.20	0.40
1990	=1 if year is 1990, = 0 otherwise	0.20	0.40
1992-DROP*	=1 if year is 1992, =0 otherwise	0.20	0.40

* Variable dropped in all regressions.

Table 2.2. Regression Results for IntraLATA Toll Rate Regression Model 1

Estimation Method: OLS

Variable	Estimate	Std. Error	t Statistic	Prob>|T|
APPOINT	0.0222	0.0075	2.9660	0.0031
CABLEPEN	-0.1334	0.0782	-1.7050	0.0883
CABLEREG	-0.0493	0.0094	-5.2530	0.0001
FORT500	-0.0017	0.0002	-7.1190	0.0001
INCOME	-0.0001	4.08E-06	-15.6890	0.0001
JANUARY	-0.0025	0.0007	-3.7390	0.0002
JULY	-0.1041	0.0261	-3.9820	0.0001
JULY2	0.0006	0.0002	3.8210	0.0001
LOBBY	0.0028	0.0012	2.3150	0.0207
REPUBLICAN	-0.0249	0.0089	-2.7930	0.0053
AMERITECH	-0.4442	0.0449	-9.8930	0.0001
BELLAT	-0.3118	0.0415	-7.5090	0.0001
BELLSTH	-0.3956	0.0502	-7.8860	0.0001
NYNEX	-0.2708	0.0418	-6.4740	0.0001
PACTEL	-0.3626	0.0511	-7.1010	0.0001
SWBELL	-0.4309	0.0485	-8.8800	0.0001
USWEST	-0.6182	0.0469	-13.1920	0.0001
0 -10 MI	-0.9719	0.0190	-51.1940	0.0001
11-16 MI	-0.8020	0.0190	-42.2430	0.0001
17-22 MI	-0.6767	0.0190	-35.6460	0.0001
23-30 MI	-0.4969	0.0190	-26.1760	0.0001
31-40 MI	-0.3598	0.0190	-18.9500	0.0001
41-55 MI	-0.2258	0.0190	-11.8940	0.0001
56-70 MI	-0.1006	0.0190	-5.2990	0.0001
1983	0.3039	0.0255	11.8950	0.0001
1986	0.3206	0.0185	17.3100	0.0001
1988	0.2399	0.0160	14.9480	0.0001
1990	0.1008	0.0151	6.6680	0.0001
INTERCEPT	6.8007	1.0303	6.6010	0.0001

N = 1920

Root MSE 0.20797 R-square 0.7824

Dep Mean 1.00361 Adj R-sq 0.7792

F Value Prob>F

242.818 0.0001

Estimation Method Fuller-Battese

Variable	Estimate	Std. Error	t Statistic	Prob>|T|
APPOINT	0.0222	0.0143	1.5598	0.1190
CABLEPEN	0.0428	0.1406	0.3041	0.7610
CABLEREG	-0.0523	0.0179	-2.9172	0.0036
FORT500	-0.0018	0.0005	-4.0658	0.0001
INCOME	-0.0001	7.61E-06	-7.6800	0.0001
JANUARY	-0.0023	0.0013	-1.8279	0.0677
JULY	-0.0896	0.0498	-1.7980	0.0723
JULY2	0.0006	0.0003	1.7341	0.0831
LOBBY	0.0027	0.0023	1.1665	0.2436
REPUBLICAN	-0.0206	0.0135	-1.5294	0.1263
AMERITECH	-0.3903	0.0847	-4.6092	0.0001
BELLAT	-0.2880	0.0791	-3.6398	0.0003
BELLSTH	-0.3526	0.0953	-3.6982	0.0002
NYNEX	-0.2309	0.0791	-2.9185	0.0036
PACTEL	-0.3221	0.0967	-3.3320	0.0009
SWBELL	-0.3887	0.0922	-4.2181	0.0001
USWEST	-0.5684	0.0884	-6.4325	0.0001
0 -10 MI	-0.9709	0.0137	-70.8305	0.0001
11-16 MI	-0.7941	0.0141	-56.3823	0.0001
17-22 MI	-0.6725	0.0142	-47.5119	0.0001
23-30 MI	-0.4644	0.0139	-33.3332	0.0001
31-40 MI	-0.3285	0.0138	-23.7611	0.0001
41-55 MI	-0.2260	0.0135	-16.7031	0.0001
56-70 MI	-0.0943	0.0131	-7.1858	0.0001
1983	0.3616	0.0446	8.1125	0.0001
1986	0.2327	0.0293	7.9324	0.0001
1988	0.1009	0.0231	4.3635	0.0001
1990	-0.0119	0.0169	-0.7086	0.4787
INTERCEPT	6.0417	1.9599	3.0827	0.0021

Number of Cross Sections 384

Time Series Length 5

Variance Component for Cross Sections 0.026216

Variance Component for Time Series 0.000008

Variance Component for Error 0.017989

SSE 36.10192 DFE 1891

MSE 0.019091 Root MSE 0.138172

Table 2.3. Regression Results for IntraLATA Toll Rate Regression Model 2

Estimation Method OLS

Variable	Estimate	Std. Error	t Statistic	Prob>[T]
APPOINT	0.0259	0.0076	3.3910	0.0007
CABLEPEN	-0.1803	0.0813	-2.2170	0.0268
CABLEREG	-0.0683	0.0126	-5.4400	0.0001
COMPACC	-0.1374	0.0513	-2.6790	0.0074
FORT500	-0.0011	0.0003	-3.3960	0.0007
INCOME	-0.0001	4.76E-06	-12.3630	0.0001
INTRACOMP	0.0041	0.0076	0.5320	0.5946
INTRACOMP*FORT500	-0.0004	0.0002	-1.6940	0.0904
JANUARY	-0.0019	0.0007	-2.6120	0.0091
JULY	-0.0984	0.0266	-3.7040	0.0002
JULY2	0.0006	0.0002	3.6100	0.0003
LOBBY	0.0034	0.0012	2.7730	0.0056
REPUBLICAN	-0.0254	0.0090	-2.8190	0.0049
AMERITECH	-0.3969	0.0476	-8.3460	0.0001
BELLAT	-0.2592	0.0452	-5.7350	0.0001
BELLSTH	-0.3721	0.0509	-7.3140	0.0001
NYNEX	-0.2144	0.0463	-4.6280	0.0001
PACTEL	-0.3818	0.0515	-7.4190	0.0001
SWBELL	-0.4070	0.0492	-8.2710	0.0001
USWEST	-0.5667	0.0503	-11.2580	0.0001
0 -10 MI	-0.9719	0.0190	-51.2850	0.0001
11-16 MI	-0.8020	0.0190	-42.3180	0.0001
17-22 MI	-0.6767	0.0190	-35.7100	0.0001
23-30 MI	-0.4969	0.0190	-26.2220	0.0001
31-40 MI	-0.3598	0.0190	-18.9840	0.0001
41-55 MI	-0.2258	0.0190	-11.9150	0.0001
56-70 MI	-0.1006	0.0190	-5.3080	0.0001
1983	0.3003	0.0265	11.3480	0.0001
1986	0.3164	0.0192	16.5030	0.0001
1988	0.2378	0.0164	14.4750	0.0001
1990	0.1002	0.0152	6.5930	0.0001
INTERCEPT	6.4321	1.0527	6.1100	0.0001

N=1920

Root MSE	0.20760	R-square	0.7835
Dep. Mean	1.00361	Adj R-sq	0.7800

F Value	220.42
Prob>F	0.0001

Estimation Method Fuller-Battese

Variable	Estimate	Std. Error	t Statistic	Prob>[T]
APPOINT	0.0260	0.0145	1.7918	0.0733
CABLEPEN	-0.0058	0.1460	-0.0394	0.9686
CABLEREG	-0.0744	0.0230	-3.2353	0.0012
COMPACC	-0.1422	0.0951	-1.4960	0.1348
FORT500	-0.0012	0.0006	-2.1423	0.0323
INCOME	-0.0001	8.73E-06	-6.0396	0.0001
INTRACOMP	-0.0030	0.0109	-0.2760	0.7825
INTRACOMP*FORT500	-0.0002	0.0004	-0.6605	0.5090
JANUARY	-0.0016	0.0014	-1.1995	0.2305
JULY	-0.0853	0.0505	-1.6899	0.0912
JULY2	0.0005	0.0003	1.6470	0.0997
LOBBY	0.0035	0.0024	1.4662	0.1428
REPUBLICAN	-0.0211	0.0135	-1.5653	0.1177
AMERITECH	-0.3446	0.0891	-3.8689	0.0001
BELLAT	-0.2359	0.0852	-2.7706	0.0057
BELLSTH	-0.3296	0.0964	-3.4203	0.0006
NYNEX	-0.1789	0.0857	-2.0871	0.0370
PACTEL	-0.3429	0.0975	-3.5183	0.0004
SWBELL	-0.3685	0.0932	-3.9540	0.0001
USWEST	-0.5180	0.0934	-5.5439	0.0001
0 -10 MI	-0.9709	0.0137	-70.8252	0.0001
11-16 MI	-0.7941	0.0141	-56.3782	0.0001
17-22 MI	-0.6725	0.0142	-47.5076	0.0001
23-30 MI	-0.4644	0.0139	-33.3303	0.0001
31-40 MI	-0.3285	0.0138	-23.7590	0.0001
41-55 MI	-0.2260	0.0135	-16.7011	0.0001
56-70 MI	-0.0943	0.0131	-7.1853	0.0001
1983	0.3535	0.0457	7.7409	0.0001
1986	0.2251	0.0302	7.4441	0.0001
1988	0.0962	0.0238	4.0492	0.0001
1990	-0.0139	0.0171	-0.8167	0.4142
INTERCEPT	5.7373	1.9911	2.8815	0.0040

Number of Cross Sections	384
Time Series Length	5
Variance Component for Cross Sections	0.026205
Variance Component for Time Series	0.000008
Variance Component for Error	0.018000

SSE	36.05526	DFE	1888
MSE	0.019097	Root MSE	0.138192

Table 2.4. Regression Results for IntraLATA Toll Rate Regression Model 3

Estimation Method OLS

Variable	Estimate	Std. Error	t Statistic	Prob>|T|
APPOINT	0.0202	0.0075	2.6900	0.0072
CABLEPEN	-0.1434	0.0809	-1.7730	0.0764
CABLEREG	-0.0871	0.0129	-6.7720	0.0001
COMPACC	-0.1195	0.0509	-2.3480	0.0190
COMPACC*FORT500	-0.0073	0.0013	-5.7170	0.0001
FORT500	0.0032	0.0008	3.8290	0.0001
INCOME	-0.0001	4.69E-06	-12.3090	0.0001
INTRACOMP	-0.0066	0.0064	-1.0360	0.3004
JANUARY	-0.0018	0.0007	-2.4790	0.0133
JULY	-0.0823	0.0263	-3.1280	0.0018
JULY2	0.0005	0.0002	3.0270	0.0025
LOBBY	0.0032	0.0012	2.5650	0.0104
REPUBLICAN	-0.0195	0.0090	-2.1710	0.0301
AMERITECH	-0.2764	0.0521	-5.3060	0.0001
BELLAT	-0.1239	0.0512	-2.4190	0.0156
BELLSTH	-0.2423	0.0557	-4.3460	0.0001
NYNEX	-0.0346	0.0564	-0.6130	0.5398
PACTEL	-0.2232	0.0578	-3.8600	0.0001
SWBELL	-0.3014	0.0525	-5.7380	0.0001
USWEST	-0.4100	0.0576	-7.1160	0.0001
0 -10 MI	-0.9719	0.0188	-51.6880	0.0001
11-16 MI	-0.8020	0.0188	-42.6510	0.0001
17-22 MI	-0.6767	0.0188	-35.9900	0.0001
23-30 MI	-0.4969	0.0188	-26.4280	0.0001
31-40 MI	-0.3598	0.0188	-19.1330	0.0001
41-55 MI	-0.2258	0.0188	-12.0090	0.0001
56-70 MI	-0.1006	0.0188	-5.3500	0.0001
1983	0.3102	0.0263	11.7890	0.0001
1986	0.3206	0.0190	16.8750	0.0001
1988	0.2380	0.0162	14.6870	0.0001
1990	0.0997	0.0151	6.6210	0.0001
INTERCEPT	5.5840	1.0449	5.3440	0.0001

N=1920

Root MSE	0.20598	R-square	0.7869
Dep. Mean	1.00361	Adj R-sq	0.7834

F Value	224.86
Prob>F	0.0001

Estimation Method Fuller-Battese

Variable	Estimate	Std. Error	t Statistic	Prob>|T|
APPOINT	0.0209	0.0143	1.4675	0.1424
CABLEPEN	0.0256	0.1449	0.1767	0.8597
CABLEREG	-0.0906	0.0234	-3.8710	0.0001
COMPACC	-0.1211	0.0941	-1.2861	0.1986
COMPACC*FORT500	-0.0070	0.0024	-2.9319	0.0034
FORT500	0.0029	0.0015	1.8620	0.0628
INCOME	-0.0001	8.60E-06	-6.0941	0.0001
INTRACOMP	-0.0089	0.0089	-0.9978	0.3185
JANUARY	-0.0016	0.0013	-1.1904	0.2341
JULY	-0.0683	0.0499	-1.3670	0.1718
JULY2	0.0004	0.0003	1.3321	0.1830
LOBBY	0.0031	0.0023	1.3484	0.1777
REPUBLICAN	-0.0176	0.0134	-1.3109	0.1900
AMERITECH	-0.2281	0.0973	-2.3450	0.0191
BELLAT	-0.1054	0.0959	-1.0987	0.2721
BELLSTH	-0.2056	0.1048	-1.9611	0.0500
NYNEX	-0.0011	0.1051	-0.0108	0.9914
PACTEL	-0.1905	0.1093	-1.7436	0.0814
SWBELL	-0.2652	0.0991	-2.6760	0.0075
USWEST	-0.3657	0.1069	-3.4211	0.0006
0 -10 MI	-0.9709	0.0137	-70.9223	0.0001
11-16 MI	-0.7942	0.0141	-56.4583	0.0001
17-22 MI	-0.6725	0.0141	-47.5551	0.0001
23-30 MI	-0.4646	0.0139	-33.3673	0.0001
31-40 MI	-0.3287	0.0138	-23.7843	0.0001
41-55 MI	-0.2259	0.0135	-16.7061	0.0001
56-70 MI	-0.0944	0.0131	-7.1958	0.0001
1983	0.3622	0.0454	7.9865	0.0001
1986	0.2309	0.0300	7.7021	0.0001
1988	0.0996	0.0235	4.2448	0.0001
1990	-0.0126	0.0170	-0.7415	0.4585
INTERCEPT	4.8623	1.9777	2.4586	0.0140

Number of Cross Sections	384
Time Series Length	5
Variance Component for Cross Sections	0.025512
Variance Component for Time Series	0.000008
Variance Component for Error	0.017996

SSE	36.07377	DFE	1888
MSE	0.019107	Root MSE	0.138228

Table 2.5. Estimates: Impact of Explanatory Variables on IntraLATA Call Prices

Model 1*

Continuous (elasticities).

Variable	Elasticity
CABLEPEN	0.02
FORT500	-0.04
INCOME	-0.76
JANUARY	-0.06
JULY	-6.76
LOBBY	0.02

Discrete (coefficients).

APPOINT	0.04
CABLEREG	-0.10
REPUBLICAN	-0.04
AMERITECH	-0.39
BELLAT	-0.29
BELLSTH	-0.35
NYNEX	-0.23
PACTEL	-0.32
SWBELL	-0.39
USWEST	-0.57
0 -10 MI	-0.97
11-16 MI	-0.79
17-22 MI	-0.67
23-30 MI	-0.46
31-40 MI	-0.33
41-55 MI	-0.23
56-70 MI	-0.09
1983	0.36
1986	0.23
1988	0.10
1990	-0.01

Model 2*

Continuous (elasticities).

Variable	Elasticity
CABLEPEN	-2.93E-03
COMPACC	-0.03
FORT500**	-0.03
INCOME	-0.68
JANUARY	-0.04
JULY	-6.44
LOBBY	0.02

Discrete (coefficients).

APPOINT	0.05
CABLEREG	-0.15
INTRACOMP**	-0.01
REPUBLICAN	-0.04
AMERITECH	-0.36
BELLAT	-0.24
BELLSTH	-0.33
NYNEX	-0.19
PACTEL	-0.36
SWBELL	-0.38
USWEST	-0.54
0 -10 MI	-0.97
11-16 MI	-0.79
17-22 MI	-0.67
23-30 MI	-0.46
31-40 MI	-0.33
41-55 MI	-0.23
56-70 MI	-0.09
1983	0.36
1986	0.23
1988	0.09
1990	-0.01

Model 3*

Continuous (elasticities).

Variable	Elasticity
CABLEPEN	0.01
COMPACC**	-0.05
FORT500**	0.03
INCOME	-0.68
JANUARY	-0.04
JULY	-5.15
LOBBY	0.02

Discrete (coefficients).

APPOINT	0.04
CABLEREG	-0.18
INTRACOMP	-0.02
REPUBLICAN	-0.04
AMERITECH	-0.23
BELLAT	-0.11
BELLSTH	-0.21
NYNEX	0.00
PACTEL	-0.19
SWBELL	-0.27
USWEST	-0.37
0 -10 MI	-0.97
11-16 MI	-0.79
17-22 MI	-0.67
23-30 MI	-0.46
31-40 MI	-0.33
41-55 MI	-0.23
56-70 MI	-0.09
1983	0.36
1986	0.23
1988	0.10
1990	-0.01

*All estimates based on variance components estimation.

**includes interaction.

CHAPTER 3

PRICING INCENTIVES UNDER PRICE-CAP REGULATION

3.1 Introduction

Relative simplicity is one of many reasons why price-cap regulation (i.e., regulation of price levels) has emerged as a popular alternative to rate-of-return regulation, especially in the telecommunications industry.[1,2,3] In the price-cap regulation plans of British Telecom and AT&T, multiple services are grouped into one or more baskets that share a single cap or ceiling. A weighted average of the prices for all services in a basket must not exceed the level of the cap. This analysis begins with a simple question: how should the average price for a basket be calculated? A stylized approximation of the FCC's price-cap plan for regulating AT&T demonstrates that the index used to calculate the average price within a basket can lead to intertemporal incentive problems that have a substantial impact

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[1] Since the firm is the residual claimant of all profits, superior incentives for cost reduction and innovation are other desirable properties of theoretical price-cap regulation. Liston (1993) compares rate-of-return regulation with price-cap regulation and discusses pitfalls of implementing either scheme.

[2] BellSouth Telecommunications (1993) reports that RI, CA, MI, ND, NJ, OR, (Rochester) NY, and WV have forms of effective price regulation plans, and AR, AZ, DE, IL, IN, OH, PA, VT, and WI have proposed plans.

[3] The experiences of British Telecom (BT) and AT&T under price-cap regulation, since 1984 and 1989, respectively, have received accolades. See Beesley and Littlechild (1989) and Cheah (1991) regarding the British experience, and see the U.S. FCC (1993) for a recent performance review of the AT&T plan.

upon social welfare.[4] This analysis provides specific demand conditions under which the incentive problems can arise and identifies two effects that help the firm to exploit these conditions.

The incentive problems are inherent in the structure of the weights used to calculate the average price for the basket. Under the FCC plan, the weight assigned to a given service is the share of total revenue for the basket generated by that service in the preceding period.[5] By manipulating the weight on a service through the prices it chooses today, the firm may be able to expand the range of feasible prices tomorrow and thereby earn a higher level of profit. The key intuition is that by setting a low price on one service today, the weight placed on that service tomorrow will be less whenever demand is inelastic. The inelastic portion of the demand curve is of particular interest since empirical estimates of the price-elasticity of demand for telecommunications services consistently reveal inelastic demand.[6] The context considered is that of a monopolist who produces two services over two periods. A single basket contains both services, and the firm is subject to price-cap regulation in both periods. The case of identical independent linear demands is the main vehicle for the analysis, but alternative settings are also discussed.

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[4] Simulations suggest that social welfare can be as much as 45% higher when the firm is prevented from manipulating the index.

[5] The FCC plan for regulating AT&T employs a rolling Laspeyres index where a weighted average of the relative price changes for all services in a basket must not exceed a specified level. The cap in the FCC plan is normalized and adjusted annually for inflation less an offset for anticipated increases in productivity (Mitchell and Vogelsang, 1991, p. 169). Using superscripts ($i = 1,..,N$) to denote services, subscripts ($t \geq 1$) to represent periods, p to represent prices, CPI to denote the percentage change in the consumer price index, and X to capture the productivity offset, the Laspeyres index may be written as $\Sigma_i (p^i_t / p^i_{t-1}) w^i_t \leq (1+CPI-X)$ for a given t. The weight $w^i_t = (p^i_{t-1}\, x^i_{t-1} / (\Sigma_i\, p^i_{t-1} x^i_{t-1}))$ is assigned to service i in period t as the share of total revenue generated by that service in the preceding period, (t - 1) (Mitchell and Vogelsang, 1991, p. 280, 285). These weights are the focal point of this analysis.

[6] Kahn and Shew (1987) cite estimates of the price elasticities of demand for telecommunications services by the residential sector as -0.02 for connection, -0.10 for access, -0.17 for local use, -0.35 for intrastate toll service, and -0.58 for interstate toll service. For the business sector, price-elasticity of demand estimates are -0.11 for local use, -0.49 for intrastate toll service, and -0.54 for interstate toll service. Also see Marfisi et. al. (1981).

The main findings of this analysis are as follows. First, two distinct effects that drive the incentives and ability of the firm to manipulate the weight structure are identified. The "value effect" arises because the amount of profit to be gained from manipulating the weights becomes greater as demand becomes less elastic. When a constraining price-cap forces the firm into an inelastic portion of the demand curve, the firm has a greater incentive to manipulate the weights. The "leverage effect" arises because weights employed in the FCC's plan become more sensitive to price variations when demand is less elastic. The two effects together can provide the firm with the incentive and the ability to manipulate the weights when the price-cap is constraining.[7] Under these circumstances, weight manipulation in which different prices are set for identical services provides greater profit for the regulated firm.

The second finding of this paper is that strategic manipulation of the weights reduces social welfare. The third finding is an alternative weighting scheme that eliminates the intertemporal incentive problem for all inelastic linear demand. Weights based on relative quantities rather than relative revenues are shown to have simple and more desirable properties.[8] As demand becomes less elastic, the magnitude of profit to be gained from weight manipulation (i.e., the "value effect") increases regardless of the weighting scheme employed. The "leverage effect," however, varies. Under "quantity weights," the leverage the firm has to manipulate the weights (i.e., the leverage effect) diminishes as demand becomes less elastic. The value and leverage effects work against one another under quantity weights, and it is shown that the firm will never manipulate the weights over the inelastic portion of demand. Since social welfare is shown to decrease unambiguously with weight manipulation, quantity weights can improve social welfare.

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[7] In the context of the model, a specific level of the price-cap below which weight manipulation becomes the profitable strategy is identified.

[8] One reason why quantity weights are not employed in practice is that the units of different commodities may be difficult to compare. With different types of telephone calls, for example, minutes or messages could serve as a basis of comparison. If, however, the number of telephone sets repaired is included in the same basket, the unit comparison is less meaningful.

Other recent articles have questioned the intertemporal performance of some forms of price-cap regulation over time.[9] In a related model, Law (1994) finds that Laspeyres index regulation--price-cap regulation under revenue weights--raises producer welfare but reduces consumer welfare in the first period. Law also shows that Laspeyres index regulation may decrease period 2 consumer welfare.[10] This paper goes further, explaining when and why weight manipulation occurs. The present analysis also provides specific conditions under which weight manipulation occurs, examines the welfare implications of weight manipulation, and proposes an alternative weighting scheme that eliminates the incentives.

The paper is organized as follows. Section II presents the elements of the model. Section III contains an analysis of the model under revenue weights. Section IV presents findings when the alternative weighting scheme, quantity weights, is employed. Section V offers simulations as examples of the firm's pricing decisions and society's welfare under some representative demand conditions. Section VI draws conclusions and discusses potential extensions of the model.

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[9] See Sappington and Sibley (1992), Neu (1993), and Law (1994).

[10] Sappington and Sibley (1992) examine incentives for welfare-reducing strategic action by a firm whose average revenue (calculated as current total revenue divided by last period's total output) is constrained not to exceed a fixed level. The firm in their model produces only one good. The firm in this analysis produces two services where a weighted average of the prices of those services is constrained not to exceed a specified level.

3.2 Elements of the Model

The firm is presumed to have a monopoly in the two services it supplies. Let p^i_t represent the price of service i = A,B in time period t = 1,2; superscripts denote services, and subscripts denote periods. For simplicity, demands for the services are assumed to be independent and identical. Furthermore, each demand is assumed to be linear and stationary. Within this setting, there is no further loss of generality in writing demand as $x^i_t = (1 - p^i_t)$.[11] Also, let $c^i = 0$, $F = 0$, and $\beta = 1$ denote the firm's constant, time-invariant marginal costs of producing service i, fixed costs, and discount factor, respectively.[12] Income effects are assumed to be absent.[13]

Before price-cap regulation begins, the regulator sets the level of the price-cap and the form of the constraint in each period. The firm takes the level of the cap as exogenous. No dynamic changes in costs and market conditions are considered. The firm also has perfect information regarding its costs and market demands in all time periods. Furthermore, by assumption, the price-cap falls below the profit-maximizing price and above the average cost of each service. The price-cap constraints for time periods one and two are given by

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[11] To see that there is no loss of generality, divide $x\,[p^i_t\,] = a - bp^i_t$ by the intercept to obtain $x\,[p^i_t\,]/a = 1 - (b/a)\,p^i_t$. Let $\hat{x} = x\,[p^i_t\,]/a$ and $\hat{p}^i_t = (b/a)\,p^i_t$, so $\hat{x}\,[p^i_t\,] = 1 - \hat{p}^i_t$.

[12] The zero cost assumption simplifies the analysis. Positive costs of production shift the area of interest--the prices above marginal cost and below the unconstrained profit maximum such that fixed costs are covered.

[13] Willig (1976) has shown that measures of consumer and producer surplus may be useful analysis tools even in the presence of nonzero income effects.

$$p^0 \geq w^A_1 \, p^A_1 + w^B_1 \, p^B_1 \text{ ; and,} \tag{3.1}$$
$$p^0 \geq w^A_2 \, p^A_2 + w^B_2 \, p^B_2 , \tag{3.2}$$

where w^i_t is the weight attached to service i in period t, and p^0 is the price-cap. Working directly with price levels simplifies the analysis somewhat and exhibits the firm's incentives for weight manipulation in the simple case of identical market demands and marginal costs.[14]

In addition to the level of the cap, the regulator also selects the type of weights, w^i_t, used to measure the relative contribution of each service towards the price-cap for the basket. The FCC plan's weights based on relative revenues of service i = A, B in period t = 1,2 consist of the revenues earned by service i in period t - 1 divided by the total revenue from both services in period t - 1:

$$w^i_t = \frac{p^1_{t-1} \, x^1_{t-1}}{p^1_{t-1} \, x^1_{t-1} \; + \; p^2_{t-1} \, x^2_{t-1}} \quad \text{for } i = A,B \text{ and } t = 1,2. \tag{3.3}$$

In keeping with the assumption of identical market demands for the two services, A and B, the first-period weights for the two services, w^A_1 and w^B_1, are assumed to both equal 0.5.[15] Once the cap level and weight form are specified by the regulator, the firm announces prices that satisfy the price-cap constraint and then satisfies all demand. In the second period, the firm repeats the pricing decision with updated weights based on the prices and quantities chosen in the first period.

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[14] With the complexity of the problem in the simple case of identical demands and marginal costs, the author was not able to obtain symbolic solutions from Mathematica with the constraints expressed in terms of price relatives. For the case of identical demands and marginal costs, the constraints in equations (3.1) and (3.2) can be shown to be equivalent to constraints expressed in terms of price relatives for small price differences.

[15] Since the market demands are identical, equal initial weights ensure no bias towards one or the other service in the firm's optimal pricing pattern.

The firm's objective is to maximize total discounted profit over both periods while satisfying the price-cap constraints. The firm's total profit is the sum of the difference between revenues and costs for the two services, A and B:

$$\pi = (p^A_1 - c^A)x^A_1 + (p^B_1 - c^B)x^B_1 - F + \beta [(p^A_2 - c^A)x^A_2 + (p^B_2 - c^B) x^B_2 - F], \qquad (3.4)$$

where β is the discount factor. By assumption, $c^i = 0$, $F=0$, and $\beta = 1$ throughout the analysis. Also, define social welfare, *S*, as the sum of profit and consumer surplus in all markets for both time periods, where consumer surplus is given by

$$cs = \sum_{i=A,B} \sum_{t=1,2} \beta^{t-1} \left(\int_{p^i_t}^{1} x^i_t \left[\tilde{p}^i_t\right] d\tilde{p}^i_t \right). \qquad (3.5)$$

The firm will act to $\underset{p^A_t\, p^B_t}{\mathrm{Max}}\ \pi$ [P]

subject to: $p^0 \ge w^A_1 p^A_1 + w^B_1 p^B_1$, and (3.6)

$p^0 \ge w^A_2 p^A_2 + w^B_2 p^B_2$. (3.7)

Before proceeding through the detailed analysis of the firm's problem, [P], consider a simple pricing benchmark and example to demonstrate how the firm may profit from weight manipulation.

Pricing Benchmark: Myopic Pricing

First suppose the firm acts myopically by maximizing profit for the current period, ignoring the potential effects of first-period prices upon second-period profit. Doing so implies the firm will set $p^A_1 = p^B_1 = p^A_2 = p^B_2 = p^0$, and profits will be

$$\Pi_{\mathrm{Myopic}} = 4p^0(1 - p^0).^{16} \qquad (3.8)$$

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[16] For a formal proof, see Myopic Pricing Benchmark in the appendix.

Example of Strategic Weight Manipulation: Non-Myopic Pricing[17]

Now suppose the firm sets the price of service A at 0 in the first period. Doing so allows the firm to charge $2p^0$ for service B in the first period, i.e., $p^A_1 = 0$, $p^B_1 = 2p^0$. Furthermore, the second period weights are now $w^A_2 = 0$ and $w^B_2 = 1$, so the firm may charge $p^A_2 = 0.5$ and $p^B_2 = p^0$. Now profits will be

$$\Pi_{\text{Strategic}} = 0.25 + p^0(1-p^0) + 2p^0(1-2p^0 \, . \qquad (3.9)$$

Comparing (2.8) and (2.9), weight manipulation is profitable if

$$0.25 + 2p^0(1-2p^0) > 3p^0(1-p^0 \, , \qquad (3.10)$$

or equivalently, if $p^0 < 0.207107$. The key intuition is that by pricing one of the services at zero, the firm can drive one of the period 2 weights to zero and thereby create infinite "leverage" with which to charge higher period 2 prices. While this strategy does yield greater profit than myopic pricing whenever $p^0 < 0.207107$, the story is more complicated. First, the weight manipulation strategy presented above is not necessarily the optimal strategy. Second, the example offers no intuition about why the price-cap value $p^0 = 0.207107$ is special.

3.3. Revenue Weight Analysis

Under revenue weights identical to those of the FCC's plan for regulating AT&T, this section describes in detail the firm's optimal pricing strategies and identifies two effects that explain why $p^0 = 0.207107$ becomes important. The social welfare effects of the weight manipulation strategy are also explained.

The firm's problem, [P], is solved most readily by examining an unconstrained form of [P]. Let $\Delta_1 \geq 0$ represent the amount by which the firm raises the first-period price of service B above the level of the price-cap, p^0. Since $w^A_1 = w^B_1 = 0.5$, the price-cap constraint forces an identical reduction, Δ_1, in the price of service A, i.e.,

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[17] The terms weight manipulation and non-myopic pricing are used interchangeably throughout the discussion.

$$p^A_1 = (p^0 - \Delta_1), \text{ and} \tag{3.11}$$
$$p^B_1 = (p^0 + \Delta_1). \tag{3.12}$$

Also, let Δ_2 denote the amount that the firm chooses to lower p^B_2 below the level of the price-cap. Then

$$p^B_2 = (p^0 - \Delta_2). \tag{3.13}$$

It follows from (3.7) that the reduction in the price of service B in period 2 allows an increase in the price of service A, given by $k\Delta_2$.

$$p^A_2 = (p^0 + k\Delta_2), \text{ where} \tag{3.14}$$
$$k = \frac{w^B_2}{w^A_2}. \tag{3.15}$$

The firm will choose the amounts Δ_1 and $\Delta_2 \in [0, p^0]$ to maximize the present discounted value of profit. Initially, $\Delta_1 > 0$ will be treated as exogenous to illustrate the mechanics of weight manipulation. In the propositions that follow, profit and welfare are expressed solely as functions of Δ_1 and p^0.

Lemma 1 describes how second-period revenue weights respond to changes in first-period prices. Let $\varepsilon^i_t = \frac{\partial x^i_t}{\partial p^i_t}\frac{p^i_t}{x^i_t} <$ represent the own price elasticity of demand for service i = A,B in the period t, and let $\varepsilon^i_t|_{p^0} = \frac{-p^0}{(1-p^0)}$ denote ε^i_t evaluated at the level of the price-cap, p^0.

Lemma 1. **For $p^0 \in (0, 0.5)$ and $\Delta_1 \in [0, p^0]$,**

$$\frac{\partial w^B_2}{\partial \Delta_1} = \frac{\left(1 + \varepsilon^B_1|_{p^0}\right)(1-p^0)\left((\Delta_1)^2 + p^0(1-p^0)\right)}{2\left[(\Delta_1)^2 - p^0(1-p^0)\right]^2} \gtreqless \text{ as } \varepsilon^B_1 \lesseqgtr |-1|. \tag{3.16}$$

Whenever demand (evaluated at the level of the price-cap) is inelastic, the expression in (3.16) is strictly positive.[18] Thus, when p^B_1 is raised by Δ_1, the weight on service B increases next period if demand is inelastic. For example, if $p^0 = 0.2$ and $\Delta_1 = 0.01$, then $w^B_2 = 0.5188$, an increase of 0.0188 over w^B_1. Notice from (3.16) that the intertemporal sensitivity of revenue weights decreases over the inelastic range of demand as demand becomes more elastic, *ceteris paribus*. At unitary elasticity, the firm's ability to manipulate the weights vanishes, i.e., the right-hand side of the equality in (3.16) is zero.

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[18] The partial derivative in (3.16) holds in the neighborhood of $D_1 = 0$. In the appendix, w^B_2 is shown to increase with D_1 at an increasing rate, so the inequalities in (3.16) are not sensitive to non-marginal changes.

The myopic pricing benchmark in section II presented the firm's optimal pricing strategy for any single period, ignoring the potential effects of first-period prices upon second-period revenue weights and, thereby, feasible prices. Lemma 2 describes elements of the regulated firm's profit-maximizing behavior when the firm does not behave myopically.

Lemma 2. **Under revenue weights if $p^B_1 > p^0 > p^A_1$, then at the solution to [P], $p^A_2 > p^0 > p^B_2$ whenever demand is inelastic; and, $p^B_2 > p^0 > p^A_2$ whenever demand is elastic.**

Lemma 2 represents non-myopic firm behavior in which the firm chooses prices to maximize the present discounted value of profit. Setting $\Delta_1 > 0$ has different effects according to whether demand is elastic or inelastic. Whenever demand is inelastic, w^B_2 increases in p^B_1 (by Lemma 1), so w^A_2 decreases. Since the market demands for the two services are identical, the firm takes the greatest advantage of the price-cap constraint in the second period by placing a higher price on the service with less weight. Thus, $p^A_2 > p^0 > p^B_2$ at the solution to [P] when demand is inelastic. When demand is elastic, w^B_2 decreases with p^B_1, so $p^B_2 > p^0 > p^A_2$ at the solution to [P] by similar reasoning. To see how non-myopic pricing can translate into increased profit graphically, consider figure 3.1.

Figure 3.1 depicts the profit areas gained and lost with non-myopic behavior (i.e., strategic weight manipulation) under totally inelastic demand. Notice that in period 1 the revenue gained by setting p^B_1 above p^0, given by rectangle "G," precisely equals the revenue lost or forgone by setting p^A_1 below p^0, given by rectangle "L." The net change in period 1 profit and welfare that results from raising $\Delta_1 > 0$ is zero. The first-period prices result in $w^B_2 > 0.5 > w^A_2$ and $k = (w^B_2 / w^A_2) > 1$ (by Lemma 2). In the second period, the firm can set p^A_2 further above the level of the price-cap than p^B_2 is below the level of the price-cap since $(p_2^A - p^0) = k(p^0 - p_2^B) > (p^0 - p_2^B$ (by equation (3.7)). The ratio $k > 1$ measures the leverage the firm has to convert increases in $\Delta_1 > 0$ into higher second-period prices via weight manipulation. The firm earns greater profit and captures more consumer surplus with non-myopic behavior than it does with myopic behavior. Moreover, non-myopic behavior under totally inelastic demand creates no deadweight loss.

Demand elasticity is central to the firm's ability to manipulate the weight structure for profit. Second-period revenue weights are most sensitive to increases in Δ_1 when demand is totally inelastic (by equation (3.16)). The more sensitive the second-period weights, the larger the $k = (w^B_2 / w^A_2) > 1$ that is attainable for any given $\Delta_1 > 0$. As demand becomes less elastic and $k > 1$ increases, the firm gains leverage that it can use to charge a wider range of second-period prices and thereby capture a higher level of profit. The increased leverage that the firm gains with less elastic demand is referred to hereafter as the "leverage effect."

While the leverage of the firm increases as demand becomes less elastic, the amount of profit attainable from strategic weight manipulation also increases, as demonstrated in figure 3.2. The period 1 (left-hand) panel of figure 3.1 has been reproduced in panel 3.2(a) for easy comparison. When demand is totally inelastic, as in figure 3.2(a), the period 1 revenues the firm gains and loses by setting $\Delta_1 > 0$ offset each other, i.e., the rectangles "G" and "L" are of the same area. Figure 3.2(b) depicts non-myopic pricing under more elastic demand. In panel 3.2(b), when $\Delta_1 > 0$, the firm gains revenues given by areas G and G', but forfeits revenues given by areas L and L'.

Rectangles G and L are of the same size. G' and L' are also of the same size. The cross-hatched rectangle in figure 3.2(b) that is adjacent to both revenue-loss rectangles (L and L') represents revenue that is forgone twice: once in setting $p^A_2 > p^0$, and a second time in setting $p^B_2 < p^0$. The firm earns less profit in period 1 by setting $\Delta_1 > 0$ than it does by setting $\Delta_1 = 0$. Thus, when demand is not totally inelastic, non-myopic behavior entails forfeiting profit in the first-period for the opportunity to reap greater total profits via weight manipulation. Additionally, non-myopic pricing under relatively more elastic demand creates deadweight loss in both periods that does not occur when demand is totally inelastic. Comparable figures may be drawn for period 2 where, with more elastic demand, the area of revenue gained by setting $p^A_2 > p^0$ becomes smaller, and the area of revenue forgone by setting $p^B_2 < p^0$ becomes larger. Altogether, the profit attainable from non-myopic behavior is greater with less elastic demand. The change in the profitability of non-myopic behavior that is attributable strictly to a change in demand elasticity is hereafter referred to as the "value effect."

Since both the value and the leverage effects increase as demand becomes less elastic, less elastic demands provide the firm with both an incentive and a means to manipulate the weight structure for profit. Propositions 1 and 2 examine directly the levels of profit and welfare earned with and without strategic weight manipulation under revenue weights. The profit gained by pricing non-myopically is given formally by

$$\mathbf{D} = \sum_{t=1,2} \sum_{i=A,B} \mathbf{p}^i_t \mathbf{x}^i_t\left[\mathbf{p}^i_t\right] - \mathbf{p}^0 \mathbf{x}^i_t\left[\mathbf{p}^0\right]. \qquad (3.17)$$

With substitution of equations (3.11)-(3.15) into equation (3.17), Proposition 1 describes a condition when the expression in (3.17) is strictly positive.

Proposition 1. If $\frac{(1-2p^0)^2}{4}\left(\frac{(k-1)^2}{(k-1)^2+2k}\right) - 2(\Delta_1)^2 > 0,$ (3.18) **then non-myopic pricing yields the greatest profit.**

The profitability of non-myopic pricing is sensitive to the level of the price-cap. The relation in (3.18) reveals that manipulating the weight structure yields the greatest profit whenever the product of two terms related to the value and leverage effects exceeds twice the square of the first-period price change. Marginal revenue (evaluated at the level of the price-cap), $(1 - 2p^0)$, captures the value effect. Marginal revenue increases as p^0 decreases and the firm faces less elastic demand. The term $(k - 1) > 0$ represents the percentage by which $w^B_1 > w^A_1$. By equation (3.7), $(k - 1)$ also gauges the percent by which the second-period markup above the level of the price-cap exceeds the second-period markdown below the level of the cap, i.e., the percent by which $(p_2^A - p^0)$ exceeds $(p^0 - p_2^B)$. Proposition 2 specifies when the expression in (3.18) is positive under revenue weights.

Proposition 2. **For all $p^0 \leq 0.211$, weight manipulation is profitable under revenue weights for all $\Delta_1 \in (0, p^0]$.**

Proposition 2 is an important extension of the results of the simple example of strategic weight manipulation presented in section II. When viewed in concert with Proposition 1, it is clear that demand elasticity at the level of the price-cap drives the firm's pricing incentives through the value and leverage effects. What is most notable is that, for any given $p^0 \leq 0.21$, the firm gains the incentive and the ability to manipulate the weight structure for any $\Delta_1 \in (0, p^0]$, not just the binary (all or nothing weight manipulation, i.e., $\Delta_1 = p^0$) strategy of the simple example. Thus, even small price differences between identical services can yield greater profit than the myopic pricing benchmark. The consideration of $\Delta_1 < p^0$ also narrowly expands the range of price-caps where weight manipulation occurs from 0.207 to 0.211.

Figure 3.3 depicts the region over D_1 and p^0 where non-myopic pricing is profitable. The wedge shape of the diagram results from the restriction that $p^0 \geq D_1$.[19] For $p^0 > 0.21$, the firm is unable to gain sufficient leverage from a first-period price difference to profit from weight manipulation, so the non-myopic solution prevails. Using numerical methods to search over all feasible p^0 and D_1 over the inelastic range of demand, Table 3.1 presents the firm's profit-maximizing prices and earnings for every feasible price-cap. The profit-maximizing price is 0.5, and the maximum profit feasible with or without weight manipulation decreases monotonically in the level of the price-cap. The firm prices non-myopically for $p^0 \leq 0.21$. For price-caps in the narrow range between 0.21 and 0.2, the optimal weight manipulation strategy does not involve a zero price. Thus, when weight manipulation occurs, the firm does not always manipulate the weights to the maximum extent possible. For price-caps below 0.2, the firm does manipulate the weights to the maximum extent possible by forcing one of the weights to zero through a zero first-period price. Using analytical methods, social welfare, $\mathcal{S}$, is shown to decrease unambiguously with manipulation of the weight structure.

Proposition 3. **For revenue weights,**

$$\mathcal{S}[\Delta_1 > 0, \Delta_2 > 0 \leq \mathcal{S}[\Delta_1 = 0, \Delta_2 = 0,$$

with equality only if demand is totally inelastic.

This section has described the mechanics of weight manipulation and has demonstrated that revenue weights can provide the firm with the incentive and ability to act non-myopically whenever $p^0 \leq 0.21$. Under these conditions, even small price differences between identical services are sufficient to make weight manipulation the most profitable strategy for the regulated firm. Since non-myopic behavior reduces social welfare, any weighting scheme that precludes non-myopic behavior will improve social welfare.

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[19] Absent this restriction, negative prices become feasible.

3.4. Quantity Weights: A Preferable Alternative

This section explores weights based on the relative quantities produced--quantity weights--as an alternative that can eliminate incentives for manipulation of the weight structure. Quantity weights on service i = A, B in period t = 1,2 consist of the quantity produced of service i in period t - 1 divided by the total quantity produced of both services in period t - 1:

$$w^i_t = \frac{x^i_{t-1}}{x^1_{t-1} + x^2_{t-1}} \quad \text{for } i = A,B \text{ and } t = 1,2. \tag{3.19}$$

Lemma 3 describes how second-period quantity weights respond to changes in first-period prices. Let a second superscript, Q, denote the use of [Q]uantity weights.

Lemma 3. For $p^0 \in (0, 0.5)$ and $\Delta_1 \in [0, p^0]$,

$$\frac{\partial w_2^{BQ}}{\partial \Delta_1} = \frac{-1}{2\left(1 - p^0\right)} < 0.^{[20]} \tag{3.20}$$

The increase in p^{BQ}_1 (that results from an increase in Δ_1) decreases w^{BQ}_2 at a constant rate that depends only upon the level of the price-cap. The intertemporal sensitivity of quantity weights, given by the magnitude of the expression in (3.20), decreases as the price-cap is reduced. As a result, the leverage effect under quantity weights decreases as the level of the price-cap decreases. For example, when $p^0 = 0.49$, an increase of 0.01 in Δ_1 reduces w^{BQ}_2 by 0.0098. By contrast, when $p^0 = 0.20$, an increase of 0.01 in Δ_1 results in a decrease in w^{BQ}_2 of 0.00625. The leverage is 1.5 times greater when $p^0 = 0.49$. The intuition presented in section III regarding the value effect also applies to quantity weights. The profitability of non-myopic behavior increases as demand becomes less elastic, *ceteris paribus*. In essence, the value effect works in the opposite direction of the leverage effect under quantity weights. Lemma 4 describes a possible weight manipulation strategy that the firm may pursue under quantity weights.

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[20] The partial derivative in (3.20) holds in the neighborhood of $D_1 = 0$ but is not sensitive to non-marginal changes in D_1 since the rate of change is constant for any given p^0. For example, for $p^0 = 0.2$, if $D_1 = 0.01$, w^{BQ}_2 decreases by 0.00625. If $D_1 = 0.2$ (20 times greater), w^{BQ}_2 decreases by 0.125 (20 times greater).

Lemma 4. **Under quantity weights, if $p^{BQ}_1 > p^0 > p^{AQ}_1$, then $p^{BQ}_2 > p^0 > p^{AQ}_2$ at the solution to [P].**

An increase in the price of service B in the first period decreases the quantity weight on service B in the second period (by Lemma 3), so the price of service B exceed the price of service A in the second-period at the solution to [P]. Proposition 1 is not specific to revenue weights. If the condition in (3.18) holds, non-myopic pricing will be profitable under quantity weights.

Proposition 4. **Under quantity weights, the firm will never manipulate the weight structure, i.e., myopic pricing always maximizes profit.**

The key to Proposition 4 is that the leverage effect becomes weaker with less elastic demand, so the firm's ability to exploit the weight structure for profit is diminished. By Propositions 2 and 3, quantity weights will improve social welfare whenever $p^0 \leq 0.21$.

3.5. Simulations

In this section, some simulations are presented to illustrate the magnitude of profitable non-myopic pricing and the associated welfare effects. Consider the case where

$p^0 = 0.2$ (See Table 3.2). Under revenue weights, the firm optimally manipulates the weight structure by setting $D_1 = 0.185$ and $D_2 = 0.018$.

As the first-period price difference between services A and B becomes larger under non-myopic behavior (i.e., from larger Δ_1 and k), social welfare decreases.[21] By this measure, $p^0 = 0.2$ is a modest example since price-caps closer to marginal cost yield larger price swings under revenue weights. For $p^0 = 0.2$, the social welfare shown in table 3.2 is 7.3 % higher under quantity weights. By comparison, when $p^0 = 0.01$ with zero marginal costs, revenue weights result in non-myopic behavior where $S = 1.37$. Quantity weights do not induce non-myopic pricing, and $S = 1.9998$: a 45% improvement. Therefore, the social welfare considerations of weight manipulation may not be trivial.

To see how revenue weights affect the shape of the profit surface differently than quantity weights, consider Figures 3.4 and 3.5. Figures 3.4 and 3.5 show a contour plot and a three-dimensional plot, respectively, of the two-period profit function under revenue weights as a function of Δ_1 and Δ_2, with prices defined by (3.11)-(3.15). Lighter colors reflect higher profit levels, and the maximum in figure 3.4 occurs where $p^A_1 = 0.015$ and $p^B_1 = 0.385$. Figures 3.4 and 3.5 demonstrate how the complexity of the second-period price-cap constraint (expressed in terms of Δ_1) under revenue weights affects the shape of the profit surface. By contrast, the comparable profit surface and contours for quantity weights, shown in figures 3.6 and 3.7, are smooth. The myopic pricing benchmark yields the global maximum under quantity weights.[22]

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[21] To see this result, partially differentiate the net welfare change in the proof to Proposition 3 with respect to first- or second-period price differences.

[22] For revenue weights, the necessary first-order conditions for a maximum are satisfied at both the prices given in Table 3.2 for revenue weights and at the prices given for quantity weights. For the solution under revenue weights given in Table 3.2, the second-order sufficient conditions for a maximum are satisfied, where the determinants of the bordered Hessian of [P] and its principal minors are: $H_2 = 0.30$, $H_3 = 1.25$, $H = H_4 = 1.28$. At the solution given for quantity weights, $H_2 = 0$ for both weighting schemes; the test is inconclusive, so a maximum is neither verified nor ruled out. The solution provided

3.6. Conslucions and Research Directions

This analysis has identified two distinct effects that drive the incentives and ability of the firm to manipulate the weight structure for profit. The "value effect" arises because the amount of profit to be gained from non-myopic pricing increases as demand becomes less elastic under revenue weights or quantity weights, so the firm has a greater incentive to act non-myopically when a constraining price-cap forces the firm into an inelastic portion of the demand curve. The "leverage effect" arises because revenue weights become more sensitive to price variations when demand is less elastic. Under revenue weights, the two effects together provide the firm with the incentive and ability to manipulate the weight structure when $p^0 \leq 0.21$. Under these circumstances, weight manipulation accomplished by even small price differences between two identical services results in greater profit for the regulated firm. This paper has also demonstrated that the firm's manipulation of the weight structure under revenue weights reduces social welfare.

This analysis has also examined quantity weights as an alternative that eliminates strategic manipulation of the weight structure for all inelastic linear demand. As demand becomes less elastic, the magnitude of profit to be gained from weight manipulation (i.e., the "value effect") increases regardless of the weighting scheme employed. The "leverage effect," however, varies. Under "quantity weights," the leverage the firm has to manipulate the weights (i.e., the leverage effect) diminishes as demand becomes less elastic. The value and leverage effects work against one another under quantity weights, and it is shown that the firm will never manipulate the weights over the inelastic portion of

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for quantity weights is the only real solution to [P] that satisfies the Kuhn-Tucker conditions for a maximum.

demand. Since social welfare has been shown to decrease unambiguously with manipulation of the weight structure, quantity weights improve social welfare whenever $p^0 \leq 0.21$.

In practice, most price-cap plans institute rate bands that restrict the amount by which the price of any individual service may vary in a given period.[23] Rate bands ensure rate stability and give the regulator additional control over the company's rate structure.[24] While this analysis has not explicitly modeled rate bands, the implications of this addition are clear from Proposition 2. Proposition 2 found that weight manipulation, even through small price differences between identical services, can yield greater profit than the myopic pricing benchmark. Thus, rate bands can reduce, but generally not eliminate, the firm's ability to profit from strategic weight manipulation.

This research may be extended in several directions. The most obvious extension is to consider more general demand and cost structures, even with independent demands. Since the leverage effect with revenue weights and linear demand increases as demand becomes less elastic, a specification of constant-elasticity demand may alleviate or exacerbate the effects of non-myopic pricing upon profit and welfare.[25] Alternatively, if demand is sufficiently convex (or marginal costs sufficiently concave) so that profit is convex, non-myopic pricing might become profitable even in a single-period model.[26]

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[23] For example, in the AT&T plan, "service band indexes" restrict rate changes for individual services to a ten percent band, i.e., five percent upwards or downwards beyond any periodic adjustment for inflation or productivity in the level of the price-cap index (PCI).

[24] Rate stability, simplicity, and public acceptability are among Bonbright's (1961) list of eight traditional rate-making or pricing attributes.

[25] With revenue weights, it should be possible numerically to locate a threshold of demand elasticity and the leverage effect where non-myopic pricing becomes profitable.

Introducing more products and baskets might enrich the framework for analyzing how baskets could best be structured under interdependent demands.[27] For example, consider a revenue-weighted basket of two services, A and B, where a complement of service B is placed in a separate regulated basket.[28] With inelastic linear demand, the additional profit the firm earns by raising p^B_1 is smaller than it is with independent demands. At the same time, the additional profit the firm captures by raising p^A_2 (and lowering p^B_2) is greater than it is with independent demands. Competition in a third market or intertemporal linkage in the demand structure (e.g., peak-load pricing) are other possible extensions.[29] This model could also be adapted to study the effects of the weight structure on incentives for expenditure on cost-reducing innovation. Finally, the model could incorporate more periods and changes over time in markets or costs.

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[26] Since, by definition, marginal revenue increases when profit is convex, profit increases faster at prices above any given p^0 than it decreases at prices below p^0. See Tirole (1989), p. 69.

[27] With a greater number of services, the leverage the firm gains by raising the price of any one service diminishes since that service accounts for a relatively smaller portion of total revenue or quantity.

[28] For example, local service (in basket 1) and block-rate long distance service (WATS plans, in basket 3) may be complements for many small businesses.

[29] Due to increased competition for AT&T, the FCC streamlined regulation of 800 toll-free services (basket 2) in May 1993. In October 1991, the FCC streamlined regulation of private network, private line, and data transmission services, i.e., part of basket 3 (US. FCC, 1993).

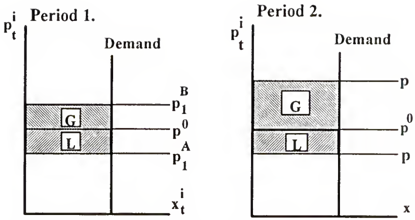
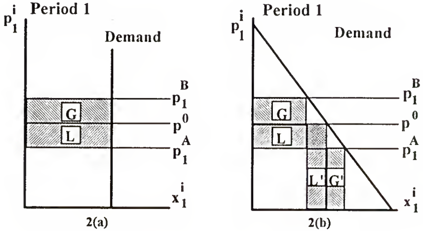


Figure 3.1. Non-Myopic Firm Behavior With Totally Inelastic Demand



2(a)

2(b)

Figure 3.2. Demand Elasticity and the Profitability of Weight Manipulation

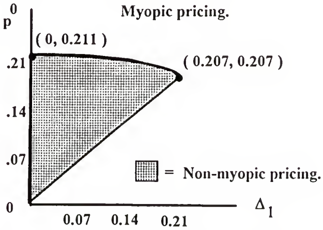


Figure 3.3 Weight Manipulation is Profitable for all $p^0 \geq 0.21$ and $\Delta_1 \in (0, p^0]$

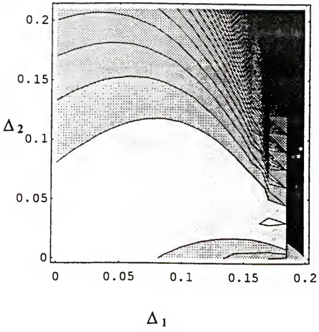


Figure 3.4. Level Curves of (D) with Revenue Weights

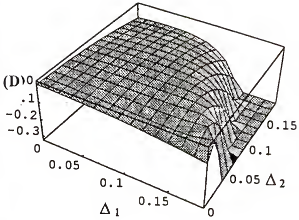


Figure 3.5. 3-D Plot of (D) with Revenue Weights.

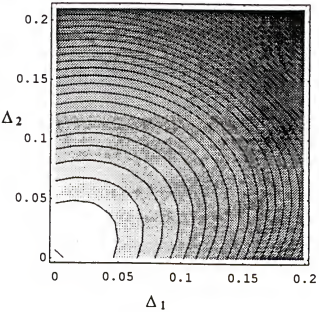


Figure 3.6. Level Curves of (D) with Quantity Weights

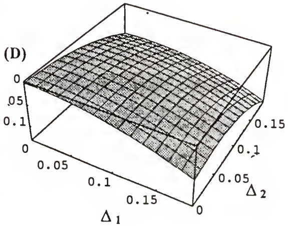


Figure 3.7. 3-D Plot of (D) with Quantity Weights

Table 3.1. Prices and Profit Levels Under Revenue Weights

P-Cap	pa1	pb1	wa2	wb2	pa2	pb2	Weight Manipulation Max Profit	Myopic Pro.	Change
0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	0.000
0.49	0.49	0.49	0.50	0.50	0.49	0.49	1.00	1.00	0.000
0.48	0.48	0.48	0.50	0.50	0.48	0.48	1.00	1.00	0.000
0.47	0.47	0.47	0.50	0.50	0.47	0.47	1.00	1.00	0.000
0.46	0.46	0.46	0.50	0.50	0.46	0.46	0.99	0.99	0.000
0.45	0.45	0.45	0.50	0.50	0.45	0.45	0.99	0.99	0.000
0.44	0.44	0.44	0.50	0.50	0.44	0.44	0.99	0.99	0.000
0.43	0.43	0.43	0.50	0.50	0.43	0.43	0.98	0.98	0.000
0.42	0.42	0.42	0.50	0.50	0.42	0.42	0.97	0.97	0.000
0.41	0.41	0.41	0.50	0.50	0.41	0.41	0.97	0.97	0.000
0.40	0.40	0.40	0.50	0.50	0.40	0.40	0.96	0.96	0.000
0.39	0.39	0.39	0.50	0.50	0.39	0.39	0.95	0.95	0.000
0.38	0.38	0.38	0.50	0.50	0.38	0.38	0.94	0.94	0.000
0.37	0.37	0.37	0.50	0.50	0.37	0.37	0.93	0.93	0.000
0.36	0.36	0.36	0.50	0.50	0.36	0.36	0.92	0.92	0.000
0.35	0.35	0.35	0.50	0.50	0.35	0.35	0.91	0.91	0.000
0.34	0.34	0.34	0.50	0.50	0.34	0.34	0.90	0.90	0.000
0.33	0.33	0.33	0.50	0.50	0.33	0.33	0.88	0.88	0.000
0.32	0.32	0.32	0.50	0.50	0.32	0.32	0.87	0.87	0.000
0.31	0.31	0.31	0.50	0.50	0.31	0.31	0.86	0.86	0.000
0.30	0.30	0.30	0.50	0.50	0.30	0.30	0.84	0.84	0.000
0.29	0.29	0.29	0.50	0.50	0.29	0.29	0.82	0.82	0.000
0.28	0.28	0.28	0.50	0.50	0.28	0.28	0.81	0.81	0.000
0.27	0.27	0.27	0.50	0.50	0.27	0.27	0.79	0.79	0.000
0.26	0.26	0.26	0.50	0.50	0.26	0.26	0.77	0.77	0.000
0.25	0.25	0.25	0.50	0.50	0.25	0.25	0.75	0.75	0.000
0.24	0.24	0.24	0.50	0.50	0.24	0.24	0.73	0.73	0.000
0.23	0.23	0.23	0.50	0.50	0.23	0.23	0.71	0.71	0.000
0.22	0.22	0.22	0.50	0.50	0.22	0.22	0.69	0.69	0.000
0.21	0.09	0.33	0.27	0.73	0.37	0.15	0.66	0.66	0.001
0.20	0.01	0.39	0.06	0.94	0.48	0.18	0.65	0.64	0.010
0.19	0.00	0.38	0.00	1.00	0.50	0.19	0.64	0.62	0.024
0.18	0.00	0.36	0.00	1.00	0.50	0.18	0.63	0.59	0.038
0.17	0.00	0.34	0.00	1.00	0.50	0.17	0.62	0.56	0.051
0.16	0.00	0.32	0.00	1.00	0.50	0.16	0.60	0.54	0.064
0.15	0.00	0.30	0.00	1.00	0.50	0.15	0.59	0.51	0.078
0.14	0.00	0.28	0.00	1.00	0.50	0.14	0.57	0.48	0.090
0.13	0.00	0.26	0.00	1.00	0.50	0.13	0.56	0.45	0.103
0.12	0.00	0.24	0.00	1.00	0.50	0.12	0.54	0.42	0.116
0.11	0.00	0.22	0.00	1.00	0.50	0.11	0.52	0.39	0.128
0.10	0.00	0.20	0.00	1.00	0.50	0.10	0.50	0.36	0.140
0.09	0.00	0.18	0.00	1.00	0.50	0.09	0.48	0.33	0.152
0.08	0.00	0.16	0.00	1.00	0.50	0.08	0.46	0.29	0.164
0.07	0.00	0.14	0.00	1.00	0.50	0.07	0.44	0.26	0.175
0.06	0.00	0.12	0.00	1.00	0.50	0.06	0.41	0.23	0.186
0.05	0.00	0.10	0.00	1.00	0.50	0.05	0.39	0.19	0.198
0.04	0.00	0.08	0.00	1.00	0.50	0.04	0.36	0.15	0.208
0.03	0.00	0.06	0.00	1.00	0.50	0.03	0.34	0.12	0.219
0.02	0.00	0.04	0.00	1.00	0.50	0.02	0.31	0.08	0.230
0.01	0.00	0.02	0.00	1.00	0.50	0.01	0.28	0.04	0.240

Table 3.2. Profit and Social Welfare Levels for [P] Under Revenue and Quantity Weights, $p^0 = 0.2$

Revenue Weights		
$p^A_1 = 0.015$	$w^A_1 = 0.50$	$\text{profit}_1 = 0.252$ $cs_1 = 0.674$
$p^B_1 = 0.385$	$w^B_1 = 0.50$	
$p^A_2 = 0.480$	$w^A_2 = 0.06$	$\text{profit}_2 = 0.398$ $cs_2 = 0.470$
$p^B_2 = 0.182$	$w^B_2 = 0.94$	
$S_{1+2} = 1.79$		

Quantity Weights		
$p^{AQ}_1 = 0.20$	$w^{AQ}_1 = 0.50$	$\text{profit}^Q_1 = 0.320$ $cs^Q_1 = 0.640$
$p^{BQ}_1 = 0.20$	$w^{BQ}_1 = 0.50$	
$p^{AQ}_2 = 0.20$	$w^{AQ}_2 = 0.50$	$\text{profit}^Q_2 = 0.320$ $cs^Q_2 = 0.640$
$p^{BQ}_2 = 0.20$	$w^{AQ}_2 = 0.50$	
$S^Q_{1+2} = 1.92$		

CHAPTER 4

REVISITING THE OLIGOPOLY PROBLEM IN ANTITRUST

4.1 Introduction

The traditional oligopoly problem in antitrust enforcement is that noncompetitive economic behavior may prevail in concentrated industries (i.e., those with few producers) without any apparent collusion among firms and, therefore, may be beyond antitrust prosecution (Blair and Kaserman, 1985). Efforts by producers, such as price-fixing, which lead to more favorable terms of sale than could be achieved in a fully competitive market are clearly anticompetitive. But a serious enforcement problem confronts legal and economic practitioners when the circumstances are not clear cut: how to apply economic theory and federal antitrust laws to adequately identify, explain, and discipline firm and industry behavior in society's best interest. Past and recent antitrust cases generally have neglected to draw upon well-defined economic models as bases for their decisions, and those that do rely upon old economic paradigms without looking for confirmation in recent theoretical oligopoly models. This paper revisits the oligopoly problem in antitrust. The first section of this paper reviews the relevant antitrust legislation, legal thinking, and precedent in antitrust since the 1960s. The second section details the most prominent, recent antitrust case involving practices that facilitate tacit collusion and compares the predictions of two economic models with the case evidence. In the third and final section, an alternative model of the case is presented and conclusions are drawn.

4.2 Legislation and Thought

The Sherman Antitrust Act (1890), the Clayton Act (1914), and the Federal Trade Commission Act (1914) are the primary legal tools in the fight against noncompetitive oligopoly behavior. In particular, section 1 of the Sherman Act prohibits "[e]very contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade." The notion of agreement to conspire or collude has become the keystone to employing Section 1. Proof of express or tacit collusion in any form constitutes agreement in this context. The applicability of Section 1 for antitrust attack on oligopoly behavior has been a source of debate. By contrast, the Clayton Act aims toward curbing specific firm behavior, such as price discrimination, exclusionary practices, and potentially anticompetitive mergers. Section 7 of the Clayton Act, which addresses horizontal, vertical, and conglomerate mergers, becomes a useful tool for preventing oligopoly formation. Finally, the Federal Trade Commission Act empowers the FTC to discipline any "unfair methods of competition . . . and . . . deceptive acts or practices in or affecting commerce" under section 5(a)(1). More recently, the FTC Act has become a means for attacking the facilitating practices employed by oligopolists.

Although many authors have analyzed the economic and legal implications of oligopolistic markets, none have revisited the case history of antitrust decisions in light of the recent advances in the economic theory of oligopolistic behavior. To lay the groundwork for a reanalysis of the oligopoly problem, some prominent articles on oligopoly theory and antitrust laws are reviewed, with emphasis on each author's theoretical economic assumptions. In chronological order, articles by Donald F. Turner, Joseph F. Brodley, Richard A. Posner, and George A. Hay are examined.

Donald Turner and "Conscious Parallelism"

Donald Turner's (1962) seminal work asks whether "consciously parallel" firm behavior is sufficient ground per se for inferring an agreement. Turner examines several decisions in antitrust cases involving oligopolies and concludes that past judgments inferring agreement consistently hinge on the existence of (additional) evidence pertaining to rigid delivered price systems, bid rigging, or resale price maintenance contracts. Without such additional evidence, Turner believes that antitrust attack of non-competitive behavior is beyond the scope of section 1 of the Sherman Act.

The rudiments of Turner's analysis of conscious parallelism lie roughly in the extended Chamberlin duopoly model. Oligopolists with symmetric costs and demands, as well as homogeneous products, recognize that a proportional share of the maximum monopoly profits can be realized by a unanimous, voluntary restraint of output below the competitive level; they are also aware how their price or quantity decision will affect other firms. With this knowledge, each firm simultaneously chooses price and quantity so as to equate marginal revenue and marginal cost relative to its proportional demand curve. Let p^m and q^m represent the profit-maximizing monopoly price and output for the industry. Then if there are n firms in the industry, each firm produces q^m/n and sells at price p^m. In this context, identical firms will do equally well on average. Each firm's share of the monopoly-level profits will exceed its share of any other feasible industry profit level, i.e., the monopoly profit level is the highest possible. This is Turner's interpretation of price leadership, and he argues vehemently that interdependent, profit-maximizing oligopolists will rationally opt for similar prices and quantities in mutual recognition of one another. Furthermore, he contends that "hardly a shade of even a 'meeting of the minds' could be said to be involved" in the setting of similar prices (Turner, 1962, p. 664). Every firm must, however, share a strong belief that none of its competitors will expand their production in pursuit of short-term interests, otherwise their restraint of output would result in lost market share and profits, rendering the behavior irrational.[1]

Imperfect information, product differentiation, cost diversity, and uncertain demand conditions often characterize real markets. Under these circumstances, Turner still asserts that rational oligopolists operating in the context of a (Chamberlin duopoly) price leadership model will unilaterally gravitate towards noncompetitive outcomes in a consciously parallel manner.[2] In general, a price leader is a firm with some advantage that enhances its market position, e.g., a moderate cost edge or a superior ability to perceive market conditions. But "collusive" price leadership may also emerge, i.e., price leadership resulting from direct or indirect agreement among firms to follow a leader. Under this scenario, firms unanimously match price increases, refrain from price reductions, and restrain output according to how the industry leader behaves, provided all other industry leaders do the same. Abstention from price reductions and the restraint of output are the linchpins to successful collusion; a loose chain of reasoning holds that unilateral price reductions lead inevitably to unanimous price reductions (price wars) and eventually to the erosion of total industry rents, so firms that are conscious of long-term profits must refrain from cheating.[3]

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[1] George Stigler suggests a probabilistic means of monitoring for cheating. Once substantial departures from agreed upon prices are detected, they will vanish since other firms will match the lower price if it is not withdrawn. This buttresses the noncompetitive price, but does not solve the cheating problem. See Stigler (1964).

[2] Detailed discussions of price leadership models may be found in Blair and Kaserman (1985), Markham (1951), and Lanzillotti (1957).

While Turner notes that banning oligopoly or monopoly pricing per se is tantamount to invoking public utility-style regulation, a firm's autonomy to set prices and quantities is not at issue here. Turner's contention that the price leadership paradigm has immunity to antitrust attack under some conditions drives his conclusion that no inference of agreement and, therefore, no credible antitrust attack is feasible under section 1 of the Sherman Act without additional, damning evidence of collusion. Absent agreement, noncompetitive price and output decisions are beyond the reach of Section 1.

Joseph Brodley's Viewpoint

Joseph F. Brodley embraces the Chamberlin model and Turner's price leadership interpretation in an analysis of legal decisions since Turner's 1962 publication.[4] At the time of Brodley's writing, new interpretations of section 7 of the Clayton Act were serving in place of the Sherman Act as preemptive means against practices that might foster oligopoly power, specifically mergers (horizontal, vertical, and conglomerate), joint ventures, and the distribution practice of consignment selling. Although "in ten major decisions since [Turner's writing] . . . the Supreme Court has struck directly at oligopoly market power, actual or threatened," Brodley (1967) maintains that further action is necessary:

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[3] Posner (1969) scrutinizes the argument that the allure of long-term gains dominates short-term profit-maximization for rational oligopolists.

[4] See Brodley (1967).

> Although the law takes no action against the static market structure of oligopoly, it should recognize the competitive danger which oligopolistic market structure poses and should act vigorously to prevent its further growth or consolidation (p. 339).

In Brodley's view, all concentrated markets, those with few firms, should be examined carefully for any behavior culpable under Section 1.[5] Wielding a sharp distinction between "tight" and "loose" oligopoly markets, Brodley emphasizes that those who employ power to allow or prevent mergers and acquisitions should pay strict attention to the potential for competition, different market definitions, and incentives for technological innovation. He believes that careful attention to these factors will lead to more efficient constriction of oligopoly power, but he offers no new analytical tools for effecting this task. At several points, Brodley addresses whether anti-oligopoly legislation has already become too restrictive: he ardently believes not (Brodley, 1967, p. 364). His conviction on this matter eclipses any concern that Turner's interpretation of the price leadership model might not adequately describe oligopolistic markets, as the next review demonstrates.

Richard Posner and Complicating Factors

Contrary to Turner and Brodley, Richard A. Posner (1969) depicts oligopolies as disguised cartels and advocates the use of Section 1 of the Sherman Act as a combatant.

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[5] Brodley cites studies by contemporary economists Bain, Hall, and Stigler as theoretical justification.

His article directly addresses Turner's viewpoint, which was prevalent at the time as evidenced by Brodley.

Posner finds Turner's behavioral assumptions to be unrealistic for several reasons. First, uncertainty or technological limitations may result in lagged price or production responses among firms. When rival firms cannot react quickly, rational firms may find irresistible the short-term profit opportunities available from unilateral price cuts and production increases.[6] Second, Turner's assertion that unilateral price cuts and quantity increases severely affect rival oligopolists may be grossly overstated, depending on the elasticity of demand and the industry concentration. Price reductions also entice new consumers into the market who were previously not able or willing to buy; this potential increase in the market size would further dampen the likely magnitude of sensitivity.

Third, Turner neglects to explain in detail how prices above the competitive level are initially established. If the industry is already at a supracompetitive price, abstinence from unilateral price reductions or production increases is only rational if all other firms in the industry are expected to do the same. The potential response lags and limited sensitivity described above suggest that, in reality, substantial short-term gains are available to firms that experiment with small price cuts and quantity increases. This is consistent with a less extreme version of J. Bertrand's (1883) classic oligopoly model of price-based competition among firms with constant marginal costs.[7] The crux of

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[6] The formal theoretical implications of time lagged responses may be traced to Stigler (1964).

[7] As noted in Krouse (1990, p.80), Bertrand argued in 1883 that homogeneous oligopolists generally, and well owners specifically, control prices and smooth demand by the use of inventory. Since quantity is at least partially predetermined by inventories, price is the basis for Bertrand competition.

Bertrand's model is that the firm setting the lowest price can supply its entire production capacity up to the level of market demand before a higher-priced firm can sell any output. If two firms set the same price, they split the market. The result is that firms bid their lowest possible price--marginal cost--and competitive price levels prevail, even in the duopoly case.[8] With the potential for substantial short-term profits from cheating and the results of Bertrand's model in hand, Posner contends that firms in reality should be reluctant to be the first in a market to raise their price(s) beyond the competitive level despite mutual knowledge of oligopolistic interdependence, unless some explicit agreement or strong mutual trust exists. For example, a large, unilateral price increase will generally result in a short-term loss of market share and profits unless other industry leaders follow suit. To Posner, forgoing a profit opportunity to follow suit is potential evidence of collusion and a path for antitrust attack. To Turner, this is merely conscious parallelism, but he offers no explicit details as to how a firm will elect to become the first to raise its price. In reality, a firm may issue price announcements and then wait to see how its rivals respond.

Posner stipulates that price leadership is a plausible explanation for the emergence of supracompetitive prices if, for example, each firm holds price steady while the industry experiences declining costs or demand. But price leadership is not consistent with downward price rigidity, a tenet of Turner's description. Firms in reality often experiment with small price cuts and quantity increases to learn the shape of the market demand curve and to pursue higher short-term returns. After a small price deviation, rational, interdependent oligopolists should revert to price leadership whenever the industry's monopoly rents appear to be in jeopardy. In Posner's view, price leadership is consistent with price and quantity experimentation, not rigidity.

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[8] Bertrand's characterization is an extreme case. Prices are the sole determinant of sales, and firms are not able to retaliate.

Posner's alternative interpretation of oligopoly behavior is in the spirit of cartel theory: collusion is feasible only when its returns exceed its costs. Naturally, the market's price elasticity of demand and entry barriers factor into the long-term viability of collusion. Inelastic demand and concentrated markets with supracompetitive prices attract entry absent substantial barriers. As the number of firms in the industry increases, each firm's share of the monopoly rents thins, provided the maximum monopoly price can be maintained at all. If all new entrants are absorbed into the cartel, the costs of coordination and enforcement eventually become prohibitive; if they are not absorbed, the new competitors will eventually undermine the cartel's market position by undercutting the supracompetitive price.

Since express collusion is easily identified and attacked, tacit means of collusion are necessary. But tacit cartel enforcement can be expensive and of limited effectiveness. Technically, tacit collusion is a type of concerted rather than unilateral activity; thus, a concerted effort--agreement--may be inferred under Section 1 if evidence of tacit collusion is discovered. Since any one firm's abstention from the pursuit of short-term profits at its rivals' expense is rational only if all others abstain, the firms behave like parties to a unilateral contract. The judicial precedent set by the Supreme Court is that Section 1 does not require proof of express collusion. By definition, express collusion is a joint effort to reap monopoly profits. Since successful tacit collusion has similar effects, its cessation falls under the jurisdiction of Section 1. In this regard, Posner advocates that the law treat express and tacit collusion as one and the same.

Posner recognizes that the problem of proof remains difficult since no direct evidence of explicit agreement, implementation, or enforcement exists. He believes, however, that a compelling case can be made by using combinations of the following kinds of circumstantial evidence:

1. Without reliable cost information, a court may infer that an industry's pricing is supracompetitive from evidence of systematic price discrimination.
2. Use of uniform delivered price systems in markets that exhibit complicating factors, such as large cost differences among firms or custom product lines, suggests that firms share an implied agreement since those who collude often decide upon a simple price scheme to reduce coordination and enforcement costs.
3. Persistent excess productive capacity leads to similar inferences since cartel members may maintain excess capacity for strategic purposes.
4. Prices of non-competing sellers should exhibit greater stability than those of competing firms. Additionally, cost changes will affect market price proportionately less in noncompetitive than competitive markets. Price leadership achieves price coordination.
5. Although excess profits can exist with marginal cost pricing, profits that consistently far exceed industry norms may be a symptom of non-competitive results.

6. Refusal to offer discounts in the face of excess capacity indicates the firm is forgoing a profitable opportunity.

7. Unnecessarily early announcements of price changes can provide a means of communicating intentions among rivals and permit time for adjustment. Early price change announcements also allow customers time to adjust. In practice, discerning between the two motives is difficult. But when the lead-time until effective price changes is lengthy and the industry's pricing behavior appears to be coordinated, it may be easier to infer tacit collusion.

8. Public statements are made by the firm as to what it considers the right price for the industry.

In the same vein that Turner noted evidence of rigid delivered price systems, bid rigging, or resale price maintenance contracts solidified the ground for antitrust attack, Posner adds evidence of tacit collusion to the list. In effect, Posner relies on (additional) evidence of tacit collusion to infer agreement under Section 1, precisely as Turner predicted was necessary under express collusion. Posner fails to undermine Turner's fundamental assertion that circumstances still exist under which noncompetitive behavior prevails but no inference of agreement can be made, so the core of the oligopoly problem still remains. The next review incorporates the possibility of circumstantial evidence and further expands the list of culpable oligopoly practices.

George A. Hay and Facilitating Practices

While Turner and Posner focus on ways to infer the existence of agreement under Section 1 of the Sherman Act, George A. Hay (1982) seeks to identify practices that facilitate collusion and violate the Federal Trade Commission Act. Under a "facilitating practices" approach, it would be unlawful for firms to achieve noncompetitive prices through the use of one or more facilitating practices. While direct (formal) collusion involves meetings or direct communications through which firms minimize uncertainty as to their rivals' actions and intentions--e.g., adopting uniform or delivered pricing arrangements (price fixing) or the territorial allocation of customers--facilitating practices may or may not involve direct contact among firms. Facilitating practices that Hay addresses include routine information exchanges, the adoption of price and product standardization systems, and the industry-wide prevalence of contractual price protection or most-favored-customer clauses. None of these practices is sufficient in itself to prove that firms tacitly collude. But together with other pieces of evidence, they can form a credible case for antitrust attack.

Hay refers to "augmented [collusive] price leadership" as a facilitating practice in itself; it is actually the context for facilitating devices. It must be noted that Hay's interpretation of price leadership is different than that to which Turner and Posner refer. As opposed to the simultaneity of the Chamberlin model, Hay speaks generally in terms of one firm setting a price and then waiting to see how others respond;[9] in timing alone, this is similar to Stackelberg's 1934 model of price leadership where firms act sequentially.[10]

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[9] In *International Harvester*, this type of price leadership survived antitrust challenge.

[10] Recall that the Chamberlin duopoly model that underlies much of Turner's reasoning and Posner's criticism involves the simultaneous selection of prices or quantities by two or more identical firms that are fully aware of how their decisions affect the industry, so each firm finds it optimal to select the monopoly price and its share of the monopoly output level. By comparison, Stackleberg price leadership can also be viewed as a simultaneous game with imperfect information where only one of the two firms is aware in the sense described above, and the other firm sets its price or output myopically.

Stackelberg price leadership permits the two firms to sequentially choose either prices or quantities. In a quantity-based game where each firm selects its optimal output, the leader enjoys a "first-mover advantage": the first firm to move produces a quantity sufficiently large to make it suboptimal for the other firm to produce as much as it would if both firms had moved simultaneously. In a price-based game with homogeneous products, there exists a "second-mover advantage": after the first firm sets its price, the second firm with sufficiently low costs has the ability to undercut the first and, thereby, capture a greater market share. After the second firm moves in either the quantity or the price game, the interaction ends. Any firm with the advantaged move can improve its profitability relative to simultaneous price or quantity competition. Likewise, the disadvantaged firm earns less than it would otherwise. A timing advantage in production or pricing is equivalent to saying that a rival is unable to respond quickly; thus when there exists a timing advantage in reality, noncompetitive market performance indicates that some firms are forgoing profitable opportunities. In this sense, Hay's interpretation overlaps with Posner's criticism. Beyond the timing, however, there are few similarities between Hay's and Stackelberg's models.

Hay distinguishes "augmented" price leadership with its reliance on some method of cartel communication about strategy and on the apparent ability and willingness of one or more industry members to discipline price cutters. For example, a concentrated industry that enjoys noncompetitive prices and is observed to announce price increases well in advance of their effective dates is suspicious. But it is not culpable on this evidence alone since customers may benefit from early price announcements. If, in addition, there is a coincident pattern of short-lived, localized price wars, that ends with the re-establishment of noncompetitive price levels, then it appears that some firm(s) are disciplining others. That is, firms that enjoy more advantageous market positions or lower costs--market leaders--may pressure lesser positioned firms into compliance with cartel price and output decisions. As few as one or two very powerful firms could dominate a large market in this manner without ever colluding in the formal sense. This is an active form of price leadership that may be discernible from merely interdependent firm behavior by examining the industry's pricing behavior. When several pieces of circumstantial evidence are accumulated, as in the above example, antitrust attack may become feasible.

As a facilitating practice, exchange or disclosure among firms of information about price, output, inventories, or investment may or may not be culpable. Perfect information among rivals firms is commonly regarded as being conducive to competition since it decreases market uncertainty and prevents the monopolistic exploitation of asymmetric information. But in a highly concentrated market, information sharing may discourage competition by providing an effective and inexpensive means of cartel monitoring.[11] The market structure and the nature of the industry heavily influence how information sharing affects the degree of competition among firms.

As with information sharing, the adoption of geographic or delivered pricing formulas may or may not encourage competition.[12] Industry-wide adoption of pricing formulas, even if done unilaterally by firms, tends to foster price stability and ease the cartel's burden of monitoring and enforcement. But in industries where firms deal with large numbers of buyers, price formulas can serve to simplify transactions. For example, firms in the overnight air-freight shipping industry routinely publish rate schedules that are based on parcel size and weight and on geographic destination (distance shipped). Without such formulas, conducting business would be quite difficult; individual consumers would attempt to negotiate private rates. Moreover, the formula permits a quick price quotation that would not be possible otherwise. This industry may be viewed as consisting of oligopolists that face a competitive fringe: Federal Express, United Parcel Service, and Airborne Express compete against the U.S. Postal Service and numerous small (local) couriers.[13]

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[11] For further description and legal case discussion of the effects information exchange specifically and facilitating practices in general, see Sullivan and Hovenkamp (1989) and Areeda and Kaplow (1988).

[12] On delivered pricing, see Stigler (1949) and Haddock (1982).

Finally, price protection or most-favored-customer clauses are also double-edged. Contractual clauses that guarantee purchasers the lowest available price within a given time period protect buyers from paying more than others. This could be an important consideration for two rival finished-good manufacturers who purchase identical intermediate goods from the same supplier. But price protection clauses also provide suppliers with strict incentives not to offer price discounts since they must refund the amount of the price discount times the quantity sold to all previous buyers in that time period.[14] Since these clauses punish firms that offer price discounts, oligopolists generally like price protection clauses when they are adopted on an industry-wide scale, and the effort necessary for cartel enforcement is decreased since customers help to enforce price discipline.

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[13] This is an imperfect example in that large corporations or institutions can generally negotiate private, discounted rates with any of these shippers, and the presence of the regulated U.S. Postal Service checks noncompetitive pricing.

[14] This assumes that customers will be able to find out if others are given price discounts. As noted by Posner and Stigler, imperfect information complicates successful collusion.

In addition to concentrating on the facilitating practices, other distinguishing features of Hay's work include consideration of a multiproduct firm and the possibility of large cost or size differences among firms; these "complicating factors" make collusion more difficult since "fair shares" are hard to agree upon. Industries offering entire product lines, multiple cost and quality levels, or differentiated products are apt to experience greater difficulty in arriving at a direct or indirect agreement on price and output.

In practice, the problem of proof under the "facilitating practices" approach remains as substantial and uncertain as with Posner's tacit collusion argument. Hay maintains that the courts traditionally have found antitrust liability only in the small subset of cases in which noncompetitive behavior can be explained as resulting directly from either formal conspiracy alone or from systematic behavior that is obviously irrational unless all firms behave the same, e.g., identical sealed bid submissions. He also notes that the courts have neglected to draw upon economic theory consistently for a basis of their decisions. As an alternative, Hay applies the facilitating practices argument to the evidence of several past legal decisions and expresses optimism that the approach will become the operative path for antitrust attack. The famous 1981 Ethyl decision, which will be discussed at length in the next section of this paper, was the first case tried by the FTC under the facilitating practices approach and served as a primary source of Hay's optimism. The Administrative Law Judge ruled that independent but noncompetitive behavior by four manufacturers of lead-based antiknock additives were liable for "indirect collusion" under section 5 of the Federal Trade Commission Act.[15] But on appeal in 1984, the Second Circuit overturned the FTC decision for reason of insufficient evidence.[16] In a 1989 article, Hay recounts that

> the Court of Appeals did not reject the basic approach, but its reversal . . . raises a question about how frequently the evidence would be strong enough to satisfy the court's criteria, except in those situations where there is enough interaction among the firms that the plaintiff can follow the traditional approach of asserting the existence of agreement (p. 202).

Hay hopes that the burden of proof will become clearly defined as more cases are tried under the facilitating practices approach. In practice, we have come full circle: although the forms that additional evidence may assume have grown and matured, 30 years have failed to undermine Turner's basic assertion that a finding of antitrust liability necessitates concrete evidence of culpable behavior. The next section of this paper analyzes the famous *Ethyl* case to examine recent economic models that may facilitate a reduction in the number and types of noncompetitive equilibria that presently escape antitrust attack.

4.3 Ethyl Example: Case and Theory

The FTC's Ethyl decision[17] and its Second Circuit reversal[18] stand as the most recent major decisions concerning the facilitating practices of collusive oligopoly behavior. The respondents--DuPont, Ethyl, PPG, and Nalco--are the only firms ever to manufacture or sell lead-based antiknock compounds in the United States. As shown in table 4.1, the producers' percentage market shares in 1974 were DuPont 38.4, Ethyl 33.5, PPG 16.2, and Nalco 11.8. The FTC found that the respondents had engaged in unfair methods of competition in violation of the FTC Act, section 5(a)(1), when each firm independently and unilaterally adopted some or all of the following practices: (1) sale of products only at delivered prices that include transportation, (2) DuPont and Ethyl's (and PPG and Nalco to a lesser extent) use of a most favored customer (also referred to as most favored nation or MFC) clause under which the seller guaranteed that no customer would be charged more than any other customer(s), and (3) DuPont and Ethyl's use of advance and public notice of price increases beyond the 30 days provided by contract.[19] Each of the challenged practices was initiated by Ethyl prior to 1948 when it was the sole producer in the industry. DuPont, Nalco, and PPG each adopted these practices upon entering the market.[20]

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[15] Re Ethyl Corp (1983).

[16] E.I. DuPont de Nemours & Co. v. FTC (1984).

[17] Re Ethyl Corp. (1983).

[18] E.I. DuPont de Nemours & Co. v. FTC (1984).

Table 4.1 Producer Market Shares

Respondent	**1974 Percent Market Share**
DuPont	38.4
Ethyl	33.5
PPG	16.2
Nalco	11.8

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[19] The most favored nations clauses in *Ethyl* were not retroactive, i.e., rebates were not offered to customers who purchased at a higher price just prior to a price decrease or discount. The clauses effectively eliminated selective discounting: any price cuts offered to one customer must be offered to all. Small refiners felt the clauses offered them security. But large producers, such as the six major oil companies that accounted for the majority of the market demand, discovered that the clauses were the most common excuse for refusal by Ethyl and DuPont to offer bids below list prices. E.I. DuPont de Nemours & Co. v. FTC (1984, p. 513).

[20] This fact was central to the Second Circuit's view that the firms each adopted the facilitating practices to compete by offering the same features as the other firms in the industry.

The court observed that the market for antiknock compounds was highly concentrated with an inelastic and severely declining demand. These features plus product homogeneity led the court to view the market as a "natural oligopoly with a high degree of pricing interdependence."[21] Government regulations limiting hydrocarbon emissions from automobiles curtailed the use of leaded gasoline and precipitated large market declines for the lead-based antiknock compounds: demand decreased 25 percent between 1976 and 1979 and by another 42 percent through 1980; an additional 75 percent decline was expected in the next decade. Despite the market decline, all four firms earned profits far exceeding the 150% average return on investment benchmark for the chemical industry. In particular, DuPont's antiknock compound business was between 70% in 1979 to 600% in 1975 more profitable than DuPont's corporate-wide average. Prices were higher than those expected from a competitive industry but lower than those expected from a monopoly.

DuPont, Ethyl, and Nalco each operated with substantial excess capacity between 1974 and 1979 while PPG had very little. Production is measured in millions of pounds of compound. In 1974 and 1975 respectively, DuPont utilized only 84 and 89 percent of its total capacity for production. For the same years, Ethyl utilized approximately 92 and 75 percent of its productive capacity.[22] With a market share of 16.2 percent, PPG's sole production facility operated (or was expected to operate) at or near full capacity during the years 1974-1978. PPG's production and capacity were reduced in 1978, and the plant was permanently closed in December 1979. While Ethyl, DuPont, and PPG had similar cost structures, Nalco employed a high-cost production process and held only 11.8 percent of the market over the same time period. The cost and capacity constraints of Nalco and PPG will become important for treating them as a competitive fringe in the modeling section of this paper.

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[21] E.I. DuPont de Nemours & Co. v. FTC (1984, p. 132).

[22] Re Ethyl Corp. (1983, pp. 444-446).

The court viewed the industry within a price leadership framework, with Ethyl or DuPont periodically "testing the waters" with a price change and retreating if necessary. But retreating was seldom necessary.[23] Figures 4.1 and 4.2 plot the prices of Ethyl and DuPont's two main varieties of antiknock compounds, TEL and TML, at the effective dates of all thirty price changes between 1974 and 1979. It is evident that the patterns of price increases largely coincide, indicating that any price change by one firm was met almost instantaneously by the other, regardless of which one initiated the change.[24] In fact, twenty of the twenty-four price increases between 1974 and 1979 were identical in magnitude and effective date; the remaining four price increases were also identical, but the effective dates varied by a day or two.

DuPont's director of marketing testified that "the second person [to announce a price change] in the market is the one who really sets the price."[25] Under the naive assumption that the first firm to move is unable to alter its declared price after the second firm announces, then the director's testimony is consistent with a description of an ordinary Stackelberg price leadership game where the second firm to set price has an opportunity to undercut the first and to capture a larger market share. In practice, the respondents announced their price changes more than 30 days in advance of the effective dates in order to maintain the flexibility to match any different announcement by a rival. Additionally, the use of meet-or-release (MOR) clauses allowed producers the opportunity to match the lowest price available in the market before losing a sale to a lower-priced rival, so even if the firms announced different prices the precise effect of the discrepancy on their total sales is not apparent. These features will be discussed at length in a model of *Ethyl* that follows this section.

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[23] Re Ethyl Corp (1983, p. 634).

[24] On one instance in July 1978, PPG initiated a price decrease. Ethyl and DuPont accounted for the remaining twenty-nine price changes between 1974 and 1979. Re Ethyl Corp (1983, p. 582).

[25] Re Ethyl Corp. (1983, p. 498).

While large refiners sought price concessions in return for quantity sales commitments, DuPont and Ethyl flatly refused to sell at discounts from list price. Nalco and PPG offered some discounts from list price, but these sales were to a small number of customers and did not result in increased percentage market shares for the firms between 1974 and 1979.[26] The cost and capacity constraints of PPG and Nalco may explain why lower prices did not earn them greater market shares. While DuPont and Ethyl engaged in some non-price competition, such as offering late billing and free technical services, PPG and Nalco were too small to compete in services. Some refiners valued these services and regarded them as a type of price discount.[27] With the services included, DuPont and Ethyl essentially offered a homogeneous product.

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[26] Re Ethyl Corp. (1983, p. 615).

[27] Re Ethyl Corp. (1983, pp. 463-464).

As for the first charge, the FTC sought to require the respondents to offer refiners the option of purchasing at a point of origin (f.o.b.) price. On the appeal, the Second Circuit emphasized the small magnitude of the freight costs--between 1.5% and 2.75% of total market price--in asserting that delivered pricing had minimal effects. The Second Circuit cited testimony by DuPont's expert witness that, in the absence of uniform delivered prices, published freight schedules would allow the firms to determine the other manufacturers' prices and match them on a case-by-case basis. The respondents asserted that the delivered prices were a convenience for their customers. But some large refiners repeatedly requested f.o.b. prices, and Ethyl and DuPont refused, even if it would have led to substantially increased business.[28] Furthermore, DuPont's Director of Marketing testified in the original trial that quoting f.o.b. prices to large customers could lead to "all kinds of problems," including, "...a general deterioration in the overall pricing of antiknock compounds."[29] Other testimony suggested that price differences of as little as 0.01 cents per pound could induce refiners to switch their business to a different antiknock compound producer.[30] If true, both statements are inconsistent with the respondents' contention and the Second Circuit's finding that the uniform delivered prices were inconsequential. Especially given the low cost of delivery, it is not clear what purpose the uniform price system served beyond facilitating price matching.

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[28] Re Ethyl Corp. (1983, p. 512).

[29] Re Ethyl Corp. (1983).

[30] This testimony would seem to be inconsistent with the fact that Nalco and PPG discounted from list price and did not expand their market shares. PPG and Nalco's capacity constraints plus the inclusion of meet or release (MOR) clauses in sales contracts help explain any inconsistencies. Re Ethyl Corp. (1983, p. 439, 498).

As to the second charge, the use of most favored customer clauses, the FTC's decision and the Second Circuit are once again at odds. The FTC found that use of the most favored customer clauses constituted an "unfair method of competition" by DuPont and Ethyl. As evidenced in the initial decision, Ethyl, DuPont, and Nalco often cited the most favored customer clause to refiners as justification for their refusal to offer discounts from list price. Both Ethyl and DuPont acknowledged that the MFC clauses reinforced price stability and feared that any transition away from MFC clauses could result in a price war.[31] Although the Second Circuit recognized the potential anticompetitive effects of industry-wide most favored customer clauses, it found "no evidence" that Ethyl or DuPont adopted or continued to use the clauses for any noncompetitive purposes. The Second Circuit also reiterated that the clauses "comport with the requirements of the Robinson-Patman Act," which prohibits price discrimination among customers that substantially lessens competition.[32]

In the initial FTC decision, the third charge of price signaling through advance press announcements of price changes was found unambiguously to increase certainty about rivals' pricing moves and to facilitate price matching. Several instances are evidenced where the advance public notices either provided the respondents with the first information about a price change or confirmed information gleaned from customers. Finding that a rival offered a different price induced price matching by the respondents. On the advice of legal counsel, three of the four respondents stopped issuing public press announcements between the spring and fall of 1977. After that time, the respondents' price information was learned from customers or from published trade reports that resulted from inquiries by the press; this introduced a slight delay in the flow of price information.

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[31] Re Ethyl Corp. (1983, p.514-515).

[32] E.I. DuPont de Nemours & Co. v. FTC (1984, p.134).

For example, DuPont announced a price increase in August of 1977. On the advice of legal counsel concerned about antitrust liability, this announcement was to take effect in just 31 days. A lead time of 30 days was provided contractually by all firms in the industry, and a notice of 33 to 39 days was typical for DuPont and Ethyl. Testimony indicated that the additional days were given with the express purpose of allowing rivals time to respond and still maintain the same effective date.[33] Two days later, Ethyl countered with a price increase of a lesser amount that was to take effect at a later date. DuPont moved shortly afterward to match Ethyl's price and effective date. The initial decision includes that

> this was the first [time] that any list price increase was intentionally undercut (F. 54-55), and Ethyl's inability to match the effective date of DuPont's price increase may have provided the incentive to undercut DuPont's price. As a result of this experience DuPont "lengthened the period somewhat . . . to provide time to test what the competitive reaction would be."[34]

Ethyl and DuPont's jockeying over the preferred price resulted in a lesser price increase effective at a later date. These results could be viewed in two ways. First, this example is consistent with Posner's contention that a time lag in either the flow of information or in a rival's ability to respond can encourage more competitive behavior. Second, the additional days of early announcement served as a means of assessing the market reaction to a price change and implementing an optimal response. In the second regard, the price announcement period may be seen as an efficient mechanism for moving from one equilibrium price to another. Given the conflicting views, is the practice objectionable? The Second Circuit asserted that the advance public notice of prices was insignificant since (1) there was already a contractual provision for 30 days notice, and (2) competitors usually heard about price increases from customers within hours. The potential impact of advance price announcements will be analyzed critically in the model of *Ethyl* that follows this section.

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[33] Re Ethyl Corp. (1983, p.617).

[34] Re Ethyl Corp. (1983, p.507).

In the end, the Second Circuit reversal challenged the FTC's authority by striking down each of its findings. While the FTC found that unilateral but interdependent conduct had lessened competition and fostered noncompetitive performance, the Second Circuit majority interpreted the FTC's authority more narrowly:

> [T]he FTC's rulings and order appear to represent uncertain guesswork rather than workable rules of law. In our view, before business conduct in an oligopolistic industry may be labeled "unfair" within the meaning of [Section] 5 a minimum standard demands that, absent a tacit agreement, at least some indicia of oppressiveness must exist such as (1) evidence of anticompetitive intent or purpose on the part of the producer charged, or (2) the absence of an independent legitimate business reason for its conduct.[35]

Additionally, the court indicated that the FTC failed to demonstrate causality beyond conscious parallelism, even if its broader formulation of Section 5 were accepted. "The mere existence of an oligopolistic market structure in which a small group of manufacturers engage in consciously parallel pricing of an identical product does not violate the antitrust laws....it could be consistent with intense competition."[36] The court maintained that the FTC's evidence did not satisfy the requirement set forth by the FTC's majority opinion: the need to "establish a clear nexus between the challenged conduct and the adverse competitive effects."[37] Although the market exhibited anticompetitive behavior, Turner's notion of conscious parallelism or oligopolistic interdependence prevailed in the Second Circuit opinion.

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[35] E.I. DuPont de Nemours & Co. v. FTC (1984, p.139).

4.4 Models of Facilitating Practices

DuPont and Ethyl's extraordinary profits, refusal to offer discounts despite the existence of excess capacity, and advance, public price announcements would seem to make this a textbook case of Posner's tacit collusion argument. Even still, the Second Circuit found the facilitating practices approach unconvincing. This section examines two efforts to explicitly model the effects and incentives of facilitating practices and then introduces an alternative model of *Ethyl*.

Cooper (1986) examines the potential for collusion in a dynamic, price-setting duopoly that employs retroactive most favored customer clauses. By reducing each firm's incentive to cut price, the clause--even adopted unilaterally--allows both firms to set higher prices and earn greater profits, so at least one firm will have an incentive to adopt a most favored customer clause in equilibrium. Consider the upward sloping price reaction functions for firms A and B above in figure 4.3; these curves depict the optimal price for each firm given the price of its rival. Without the MFC clause, prices p^A and p^B prevail in

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[36] E.I. DuPont de Nemours & Co. v. FTC (1984, p.139).

[37] E.I. DuPont de Nemours & Co. v. FTC (1984, p.141).

Bertrand competition. If either firm attempts to raise its price in this context, it will lose market share.[38] When firm A unilaterally employs a retroactive MFC clause, the cost of the necessary refunds creates a flat spot its reaction curve; that is, firm A's best response to any price by firm B between p^B and $p^{B'}$ is to maintain price $p^{A'}$. The results of this model depend critically upon the assumption that the clauses are retroactive; if price is lowered today, the amount of the price reduction must be refunded to all other customers on all purchases during the period covered by the clause.[39] Cooper's article intimates that explicit modeling of the facilitating practices can yield clear pictures of firms' profit incentives for collusion under certain conditions. The retroactive nature of the clauses and the fact that the products are differentiated in Cooper's model will not allow application of his results to *Ethyl.*[40] In *Ethyl*, the compounds were physically homogeneous although there seemed to be some difference in the services.[41] Moreover, the MFC clauses were only prospective, not retroactive.

Holt and Scheffman (1985) better approximate the behavior in *Ethyl*. In a homogeneous product and symmetric cost oligopoly setting, they model the incentives for a given firm to discount unilaterally from a supracompetitive market price. In their sales contracts, all firms employ a meet or release (MOR) clause, and at least one firm also uses a most favored customer (MFC) clause. The MOR clause specifies that the buyer has the privilege to escape from the sales contract if the producer fails to match the lowest (verifiable) price offered in the market.[42] The MFC clause in this model is not retroactive; it simply says that a discount offered by a producer to one customer must be offered to all customers thereafter.

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[38] Since Cooper (1986) assumes that products are differentiated, price discrepancies in Bertrand competition do not result in a total loss of sales to the high-price firm.

[39] It has become popular among some retailers to offer refunds to any and all customers if price is cut within 30 days of the purchase, e.g., Gateway computers and Circuit City consumer electronics.

[40] Differentiated products blunt the Bertrand incentives of price competition, so a high-price firm in the market will not lose all its market share. In *Ethyl*, meet or release clauses appear to have been the frictional force on Bertrand incentives.

[41] Nalco and PPG were unable to emulate the service offerings of Ethyl and DuPont. With the services included, Ethyl and DuPont offered a homogenous product.

Holt and Scheffman note that almost all of the antiknock customers bought from at least two suppliers and some bought from all four.[43] This fact and the inclusion of the meet or release clause assures that each buyer will obtain the lowest price available in the market. Holt and Scheffman's second proposition states that at least one firm will have an incentive to offer a discount unilaterally at any price level above that which prevails under a Cournot quantity-setting game. Intuitively, this is akin to the firms' employing Nash-Cournot output conjectures. By cutting price, the discounter conjectures that its rivals will continue to sell their optimal output, calculated at the higher price. Since rivals will match any price discount due to the MOR clause, there is no change in the market shares. Naively, the discounter of proposition two assumes that it will gain all new sales in the market that result from the lower price, so its incentives are exaggerated.[44] Without this assumption, there may well be prices above the Cournot level that are impervious to nonselective discounting. A more realistic assumption would have been that the discounter gains new customers in proportion to its market share.

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[42] Meet or release clauses are not explicitly mentioned in the *FTC Decisions* document, but Holt and Scheffman state that MOR clauses were used in the sales contracts of the antiknock compound producers in Ethyl.

[43] Re Ethyl Corp. (1983, p. 439).

[44] Recall that the MOR clause specifies that all other firms match the discount, so there is no market share to be gained from price discounts, just the increased demand that accompanies the lower price.

In the absence of both MOR and MFC clauses, a competitive price equal to marginal cost for each firm should prevail in the market; any sustained supracompetitive price would probably indicate the presence of collusion, or so it would seem that Posner would argue. With the clauses in this model, firms are able to act unilaterally in mutual recognition of one another to sustain any price up to at least the Cournot price level, as indicated above in the description of their second proposition. Holt and Scheffman also address the possibility of large cost differences among producers that result in the high-cost firms serving as a competitive fringe to the market. Under this scenario, the highest sustainable price level, i.e., where no firm wishes to discount nonselectively, may fall below the Cournot price level.

After establishing the sustainable price ranges under the MFC and MOR clauses, Holt and Scheffman address the potential impact of the advance price notification practice. They conclude that advance notification will result in a common list price equal to the lesser of the firms' preferred common prices if:

(1) the firm with the lowest preferred price has sufficient capacity to prevent others from operating profitably at higher prices, and

(2) discounting from final list prices is not permitted.[45]

The first condition says that a firm's capacity must be sufficiently large in order for it's preferred price to be a credible threat to its rivals. For example, suppose one firm prefers a supracompetitive price p^*, where $p^* < p$, and p is the price preferred by all the firm's rivals. If this one firm is too small relative to the market, the other firms can just sell their output at their preferred price(s) to the residual demand after all the low-price firm's capacity at price p* is extinguished. The second condition states that for the lowest preferred price, p^*, to be sustainable, no firm can have an incentive to price discount. While Holt and Scheffman's results are correct, they do not revisit the facts of *Ethyl*. It is not apparent how the pricing behavior in *Ethyl* corresponds to the ranges established in their model, and no comparisons are made between the producer's profitability with and without the advance price notification. They do not explicitly model the advance notification practice. The following model strives to capture some these features and to make relevant comparisons.

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[45] Re Ethyl Corp. (1983, p. 40).

4.5 An Alternative Model Of Ethyl: The Efficacy Of Price Announcements

Holt and Scheffman's approach began at a supracompetitive price and examined the incentives for unilateral price discounting. The model developed below compares the equilibria that prevail in a price game between two firms that employ meet or release (MOR) clauses with and without advance price announcements. The Second Circuit reversed the FTC's condemnation of the advance notice practice for the reasons that (1) there was already a contractual provision for 30 days notice, and (2) competitors usually heard about price increases from customers within hours. Typically, 33 to 39 days' notice was given, and the companies stated that the extra notice was precisely for the purpose of allowing competitors time to respond and still maintain the same effective date.[46] Should this practice have been viewed as a culpable effort to facilitate the noncompetitive market outcome? The following model suggests that the Second Circuit's intuition was correct.

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[46] Re Ethyl Corp. (1983, p. 617).

Suppose there are two firms, A and B, that produce a homogeneous good with constant marginal costs of production, c^A and c^B. Suppose also that the firms compete on the basis of price for the residual demand in a market with perfect information. Initially, there are no price announcements. The two firms simultaneously or sequentially offer sales contracts to all buyers to deliver an unspecified quantity at a given price. Price discrimination is not feasible. Furthermore, all contracts include a meet-or-release (MOR) clause that requires the firm to either match the lowest price offered in the market or to release the buyer from any contractual obligation. Let D(p) denote a downward-sloping, weakly concave market demand as a function of the lowest price offered by either firm, so the market share captured by firm i = A,B, is

$$D^i(p) = \left\{ \begin{array}{ll} D(p) & \text{if } p^j > p^i \\ D(p)/2 & \text{if } p^j = p^i \\ 0 & \text{if } p^i > p^j \end{array} \right\}, \quad \text{and } p = \min [\, p^A, p^B \,], \; i, j = A,B. \qquad (1)$$

The MOR clause contained in the sales contracts will result in an equilibrium market price of $p = \min [\, p^A, p^B \,]$. The effect of the meet or release (MOR) clause is to nullify the Bertrand incentives of usual homogeneous-product price competition, so the duopolists may split the market. Let p^{A^m} represent the unconstrained profit maximizing price for firm A, where $\pi = [p^i - c^i]\, D(p)$. The following assumptions are assumed to hold:

(A1) $c^A \leq c^B$

(A2) $p^{A^m} > c^B$

(A3) $\dfrac{D(p^{A^m})}{2}(p^{A^m} - c^A) \geq ((c^B - \varepsilon) - c^A)\, D(c^B)$

Assumption 1 establishes that firm A has at least weakly lower marginal costs of production. Assumption 2 states that the unconstrained monopoly price of the low-cost firm A exceeds the marginal cost of the high-cost firm B. Assumption 3 states that the firm A earns at least as much profit by splitting the market at its unconstrained profit-maximizing price as it does by charging a price just below the marginal cost of firm B.

Proposition 1

> Suppose A1-A3 hold. Any price pair (p^A, p^B) with $p^A \in [c^B, p^{A^m}]$ and $p^B \geq c^B$, with $p^A = p^B$ by the MOR clause, is a Nash equilibrium. There are no other equilibria.

Proof of Proposition 1

> The MOR clause assures $p = \min [p^A, p^B]$. $p^A \geq c^B$ by (A3). $p^{A^m} \leq p^{B^m}$ by (A1) and weakly concave demand. Since $\frac{d\pi'}{dp} = 0$ at p^{i^m} by definition, i= A,B, $c' < p^i \leq p^{i^m}$ (by A3). For all $p^i \in [c^B , p^{A^m}]$, if $p' > p^j$, then $D' = 0$, $\pi' = 0$, $D^j = D (p^i)$, and $\pi = [p^j - c^j] D(p^j)$ for i = A,B and j = A,B. Since $\pi = [p' - c^i] \frac{D(p^j)}{2} > 0$, both firms serve half of the market at p with the MOR clause in effect. Q.E.D.

Proposition 2

> Suppose A1-A3 hold. Both firms have weakly dominant strategies of offering contracts at their profit-maximizing prices.

Proof of Proposition 2

> At any p^i such that $c^B < p^i < p^{A^m}$, $p = \min [p^A, p^B]$ (by Prop. 1). Since demand is weakly concave and $p^{A^m} \leq p^{B^m}$, $\frac{d\pi'}{dp} > 0$ for all $p < p^{A^m}$. Also $\frac{d\pi^A}{dp} < 0$ for all p $> p^{A^m}$ by definition of p^{A^m} Thus, $p^A = p^{A^m}$, and Firm B is indifferent to naming p^B such that $p^{A^m} \leq p^B \leq p^{B^m}$ (by MOR clause). Q.E.D.

The lowest market price is always matched using the MOR clause. Prices above p^{A^m} are never offered by the low-cost firm A, so the range where prices may be matched is $c^B < p < p^{A^m}$. If one firm offers a higher price than the other, opting not to employ the MOR clause results in zero profit, so in equilibrium the MOR clause is always employed.

Thus, neither firm desires a different price given that of its rival when $c^B < p < p^{A^m}$. By definition, higher prices yield higher levels of profit below the profit maximum. Firms may announce prices below their monopoly prices, but would be foolish to do so. The unconstrained profit maximum is thus a focal point for firm A. With the MOR clause in effect, firm B is indifferent to any price equal to or greater than firm A's profit-maximizing price.

The introduction of a period of advance price announcements alters the results of this model in two ways. First, the advance announcement period essentially makes the MOR clauses redundant provided the firms use their ability match the lowest announced price with a later announcement of an identical price. Second, with price-announcements, the declared prices may be adjusted upwards as well as downwards. Since there are no reputation issues in a simple one-period games such as this one, there is nothing to prohibit a firm from simply announcing a higher price tomorrow than the one announced today. Price announcements below the low-cost firm's unconstrained profit maximum amount to sub-optimal--out of equilibrium--behavior for both firms. But, in this case, the advance announcement period provides a mechanism for climbing back to the preferred equilibrium. With or without an advance price announcement period, the above model suggests that the lowest preferred monopoly price will prevail in the market; this is consistent with the Second Circuit's beliefs. Absent clauses and the advance announcement practice, however, Bertrand incentives should reassert themselves. Compared to *Ethyl*, the MOR clause effectively nullifies price discrepancies that might arise without the use of the uniform delivered price system.

As for the MFC clauses, a prospective most favored customer clause effectively guarantees against selective price discounting: a discount offered to one buyer will be offered to all buyers. By contrast, an MOR clause is a type of global MFC clause: a discount offered to one customer (by another firm) will be offered to all customers (by all firms) whenever possible. The MOR clauses essentially say that a discount of any size by any firm will become an industry-wide discount. So, do the meet or release clauses then constitute a facilitating practice that is culpable under antitrust laws? The question really should ask what combinations of practices foster illegal noncompetitive results. The answer is remains quite complicated since, in a different context, such as the market for computer hardware and software, a promise by a firm to match the lowest going price could just as easily foster price competition. More important, it would not be possible or desirable to prohibit firms from announcing that they will try to meet their competitor's best price without seriously infringing upon their autonomy: precisely Turner's argument. So, what have we learned?

4.6 What have we learned?

In practice, we do not seem to be any closer to resolving the oligopoly problem in antitrust than Turner was in 1962. This paper has demonstrated that explicit modeling of the facilitating practices may shed light on the sources of a firm's or industry's incentives. The *Ethyl* market had an unusually simple structure: inelastic demand, homogeneous products, identical costs, entry barriers, and perfect information. In this regard, the simple model presented above captures important features of the real case. The model above suggests that the antiknock producers' ability to price noncompetitively stems directly from the MOR clauses or the advance price announcements, not from oligopolistic interdependence. Absent these practices, Bertrand incentives persist in the model.

An interesting direction for future research would seek to identify observable conditions under which the MFC and MOR clauses are foster competitive behavior. It also may be valuable to introduce convex increasing costs for DuPont and Ethyl. A well known result is that there is no stable equilibrium to the Bertrand game with increasing marginal costs. But the MOR clauses may effectively remedy this problem since an opportunity for price matching will exist; a multiplicity of equilibria should exist in this setting. An interesting and realistic wrinkle to model would have only a portion of the buyers signing sales contracts, where those buyers that do not sign contracts would not necessarily give a high-priced firm the opportunity to match the lowest market price.

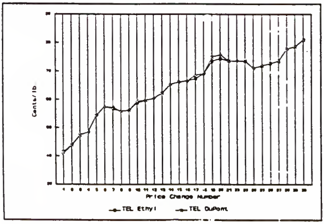

Figure 4.1 TEL Prices of DuPont and Ethyl

Source: Re Ethyl Corp et al., Appendix D.

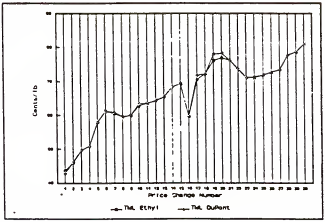

Figure 4.2 TML Prices of DuPont and Ethyl

Source: Re Ethyl Corp et al., Appendix D.

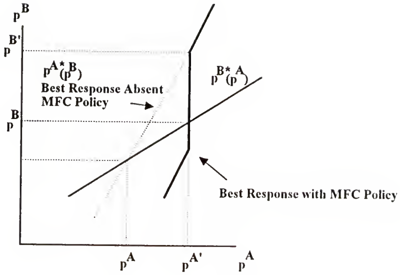

Figure 4.3 Reaction Function with MFC Policy

CHAPTER 5

CONCLUDING COMMENTS

This dissertation is composed of three essays on pricing behavior focused primarily on the telecommunications industry. Theoretical models, empirical analysis, and case study analysis have been used to explain pricing behavior.

The first essay developed and tested a stylized model of price setting in a state regulatory environment. The empirical investigation of intraLATA toll prices (1983-1992) finds that state statutory allowance of facilities-based intraLATA toll competition is not a major force that drives toll prices lower, even when the market size is taken into consideration; this result might be explained by the absence of 1+ intraLATA toll dialing parity. A number of results suggest that intraLATA toll rates are lower in states where consumers votes are more sensitive to price. In particular, intraLATA toll rates are found to be significantly lower in states with (1) elected regulatory commissioners, (2) Republican control of both the governor's seat and a majority in the state legislature, (3) higher personal income per capita, (4) less rent-seeking in the state legislature, (5) lower costs of living and more temperate climates, and (6) more large industrial consumers. Additionally, the analysis finds evidence that toll rates are significantly lower in states where threats of entry from competitive access providers and cable television are larger;

entry by these competitors may take with it the revenues earned in the markets for toll, basic local service, and access.

In terms of future research, the empirical investigation suggests several possibilities. A promising direction for analysis is a detailed study of comparative performance by elected and appointed commissioners. If elected regulators are more sensitive to constituents' concern for prices, as the results here suggest, an important question is whether these same states have experienced lower quality or slower adoption of new technologies. Another direction for research is a detailed analysis of the relationship between state commission authority and regulatory policy. More specifically, among state commissions of comparable size and budgetary resources, it would be insightful to know what factors most contribute to lower rates, e.g., scope of authority, stringency in monitoring (auditing), choice of regulatory techniques and policies. The significant findings on threats of entry suggest the need for a more detailed examination of the respective roles of cable and competitive access providers as they make inroads into telephony. There are also many other dimensions of state-level telecommunications to study, such the relationships among prices, technologies, costs, threats of entry, and interconnection, that fall beyond the present analysis.

The second essay has identified two distinct effects that drive the incentives and ability of the firm to manipulate the weight structure of a price-cap constraint for profit. The "value effect" arises because the amount of profit to be gained from non-myopic pricing increases as demand becomes less elastic under revenue weights or quantity weights, so the firm has a greater incentive to act non-myopically when a constraining price-cap forces the firm into an inelastic portion of the demand curve. The "leverage effect" arises because revenue weights become more sensitive to price variations when demand is less elastic. Under revenue weights, the two effects together can provide the firm with the incentive and ability to manipulate the weight structure. Weight manipulation accomplished by even marginal price differences between two identical services results in greater profit for the regulated firm. This essay also has demonstrated that the firm's manipulation of the weight structure under revenue weights reduces consumer welfare.

The second essay also has examined quantity weights as an alternative that eliminates strategic manipulation of the weight structure for all inelastic linear demand. As demand becomes less elastic, the magnitude of profit to be gained from weight manipulation (i.e., the "value effect") increases regardless of the weighting scheme employed. The "leverage effect," however, varies. Under "quantity weights," the leverage the firm has to manipulate the weights (i.e., the leverage effect) diminishes as demand becomes less elastic. The value and leverage effects work against one another under quantity weights, and it is shown that the firm will never manipulate the weights over the inelastic portion of demand. Since social welfare has been shown to decrease unambiguously with manipulation of the weight structure, quantity weights can improve social welfare.

In terms of future research, the essay on price-cap regulation may be extended in several directions. The most obvious extension is to consider more general demand and cost structures, even with independent demands. Since the leverage effect with revenue weights and linear demand increases as demand becomes less elastic, a specification of constant-elasticity demand may alleviate or exacerbate the effects of non-myopic pricing upon profit and welfare. Alternatively, if demand is sufficiently convex (or marginal costs sufficiently concave) so that profit is convex, non-myopic pricing might become profitable even in a single-period model. Introducing more products and baskets might enrich the framework for analyzing how baskets could best be structured under interdependent demands. For example, consider a revenue-weighted basket of two services, A and B, where a complement of service B is placed in a separate regulated basket. With inelastic linear demand, the additional profit the firm earns by raising p^B_1 is smaller than it is with independent demands. At the same time, the additional profit the firm captures by raising p^A_2 (and lowering p^B_1) is greater than it is with independent demands. Competition in a third market or intertemporal linkage in the demand structure (e.g., peak-load pricing) are other possible extensions. This model could also be adapted to study the effects of the weight structure on incentives for expenditure on cost-reducing innovation. Finally, the model could incorporate more periods and changes over time in markets or costs.

The third essay has demonstrated that explicit modeling of the facilitating practices may shed light on the sources of a firm's or industry's incentives. The *Ethyl* market had an unusually simple structure: inelastic demand, homogeneous products, identical costs, entry barriers, and perfect information. In this regard, the simple model presented above captures important features of the real case. The model above suggests that the antiknock producers' ability to price noncompetitively stems directly from the MOR clauses or the advance price announcements, not from oligopolistic interdependence. Absent these practices, Bertrand incentives persist in the model. An interesting direction for future research would seek to identify observable conditions under which the MFC and MOR clauses are foster competitive behavior. It also may be valuable to introduce convex increasing costs for DuPont and Ethyl. A well known result is that there is no stable equilibrium to the Bertrand game with increasing marginal costs. But the MOR clauses may effectively remedy this problem since an opportunity for price matching will exist; a multiplicity of equilibria should exist in this setting. An interesting and realistic wrinkle to model would have only a portion of the buyers signing sales contracts, where those buyers that do not sign contracts would not necessarily give a high-priced firm the opportunity to match the lowest market price.

APPENDIX

PROOFS TO CHAPTER 3 LEMMAS AND PROPOSITIONS

Proof of Lemma 1

Substituting (3.11) and (3.12) into (3.3) and simplifying gives

$$\frac{\partial w_2^B}{\partial \Delta_1} = \frac{\partial}{\partial \Delta_1}\left(\frac{(p^0+\Delta_1)(p^0+\Delta_1-1)}{2\left((\Delta_1)^2 - p^0 + (p^0)^2\right)}\right). \tag{3.21}$$

Using the quotient rule and simplifying gives

$$= \frac{(1-2p^0)\left((\Delta_1)^2 + p^0(1-p^0)\right)}{2\left((\Delta_1)^2 - p^0(1-p^0)\right)^2},$$

$$= \frac{\left(1+\varepsilon_1^B|_{p^0}\right)(1-p^0)\left((\Delta_1)^2 + p^0(1-p^0)\right)}{2\left[(\Delta_1)^2 - p^0(1-p^0)\right]^2}, \tag{3.22}$$

where $\varepsilon_1^B|_{p^0} = \frac{\partial x_1^B}{\partial p_1^B}\frac{p^0}{x_1^B[p^0]} = \frac{-p^0}{(1-p^0)}$.

When demand is inelastic, $|\varepsilon_1^B| < |-1|$ and the expression in (3.22) is strictly positive. The partial derivative simplified in (3.22) holds in the neighborhood of $\Delta_1 = 0$. When D_1 represents a non-marginal change, we need only to verify that w_2^B is monotonically increasing in $p^0 \in (0, 0.5)$ and $\Delta_1 \in [0, p^0]$.

$$\frac{\partial^2 w_2^B}{\partial (\Delta_1)^2} = \frac{-\Delta_1(1-2p^0)\left(3p^0(1-p^0) + (\Delta_1)^2\right)}{\left((\Delta_1)^2 - p^0(1-p^0)\right)^3} > 0. \tag{3.23}$$

The numerator of the expression in (3.23) is always negative when demand is inelastic. To see that the denominator is always negative, examine the maximum value that Δ_1 can assume, i.e., $\Delta_1 = p^0$. At this value, the denominator equals $\left(2(p^0)^2 - p^0\right)^3 < 0 \ \forall \ p^0 \in (0, 0.5)$. Thus, for any smaller values of Δ_1, the denominator is also negative. Hence, the expression in (3.23) is strictly positive for $p^0 \in (0, 0.5)$ and $\Delta_1 \in [0, p^0]$. Therefore, w^B_2 is increasing in Δ_1 at an increasing rate. Q.E.D.

Necessary First-Order Conditions for [P]

Let λ_1 and λ_2 denote the Lagrange multipliers associated with the first- and second-period price-cap constraints, respectively, and let L be the Lagrangean for [P]:

$$L = \pi + \lambda_1 (p^0 - w^A{}_1 p^A{}_1 + w^B{}_1 p^B{}_1) + \lambda_2 (p^0 - w^A{}_1\, p^A{}_1 + w^B{}_1\, p^B{}_1). \qquad (3.24)$$

At a maximum, the following conditions must hold:

$$p^A{}_1: \quad x^A{}_1 + (p^A{}_1 - c^A)\frac{\partial x^A_1}{\partial p^A_1} - \lambda_1 w^A{}_1 - \lambda_2 (p^A{}_2 - p^B{}_2)\frac{\partial w^A_2}{\partial p^A_1} = 0, \quad \forall\ p^A{}_1 > 0. \qquad (3.25)$$

$$p^B{}_1: \quad x^B{}_1 + (p^B{}_1 - c^B)\frac{\partial x^B_1}{\partial p^B_1} - \lambda_1 w^B{}_1 - \lambda_2 (p^A{}_2 - p^B{}_2)\frac{\partial w^A_2}{\partial p^B_1} = 0, \quad \forall\ p^B{}_1 > 0. \qquad (3.26)$$

$$p^A{}_2: \quad \beta [\, x^A{}_2 + (p^A{}_2 - c^A) \frac{\partial x^A_2}{\partial p^A_2} \,] - \lambda_2 w^A{}_2 = 0, \qquad \forall\ p^A{}_2 > 0. \qquad (3.27)$$

$$p^B{}_2: \quad \beta [\, x^B{}_2 + (p^B{}_2 - c^B) \frac{\partial x^B_2}{\partial p^B_2} \,] - \lambda_2 w^B{}_2 = 0, \qquad \forall\ p^B{}_2 > 0. \qquad (3.28)$$

$$\lambda_1: \quad p^0 - w^A_1 p^A_1 - w^B_1 p^B_1 = 0, \qquad \forall\ \lambda_1 > 0. \qquad (3.29)$$

$$\lambda_2: \quad p^0 - w^A_2 p^A_2 - w^B_2 p^B_2 = 0, \qquad \forall\ \lambda_2 > 0. \qquad (3.30)$$

Myopic Pricing Benchmark

With identical market demands, $w^A{}_1 = 0.5 = w^B{}_1$ by assumption. If $p^A{}_1 = p^B{}_1 = p^0$, then $w^A{}_2 = 0.5 = w^B{}_2$ by identical market demands. Since $w^A{}_2 = 0.5 = w^B{}_2$, $p^A{}_2 = p^B{}_2 = p^0$ by (3.27), (3.28), and (3.30). Q.E.D.

Proof of Lemma 2

With identical market demands, $w^A{}_1 = 0.5 = w^B{}_1$. If $p^B{}_1 > p^0 > p^A{}_1$ and demand is inelastic, then $w^B{}_2 > 0.5 > w^A{}_2$ (by Lemma 1). If $w^B{}_2 > 0.5 > w^A{}_2$, then $p^A{}_2 > p^0 > p^B{}_2$ by (3.27), (3.28), and (3.30). If $p^B{}_1 > p^0 > p^A{}_1$ and demand is elastic, then $w^A{}_2 > 0.5 > w^B{}_2$ (by Lemma 1). If $w^A{}_2 > 0.5 > w^B{}_2$, then $p^B{}_2 > p^0 > p^A{}_2$ by (3.27), (3.28), and (3.30). Q.E.D.

Proof of Lemma 3

Substituting (3.11) and (3.12) with (superscripts denoting quantity weights) into (3.19), simplifying, and differentiating gives

$$\frac{\partial w_2^{BQ}}{\partial \Delta_1} = \frac{\partial}{\partial \Delta_1}\left(\frac{1-\Delta_1-p^0}{2(1-p^0)}\right) = \frac{-1}{2(1-p^0)}. \text{ Q.E.D.}$$

Proof of Lemma 4

With identical market demands, $w^{AQ}_1 = 0.5 = w^{BQ}_1$ by assumption. If $p^{BQ}_1 > p^0 > p^{AQ}_1$ then $w^{AQ}_2 > 0.5 > w^{BQ}_2$ (by Lemma 3). If $w^{AQ}_2 > 0.5 > w^{BQ}_2$, then $p^{BQ}_2 > p^0 > p^{AQ}_2$ by (3.27), (3.28), and (3.30). Q.E.D.

Proof of Proposition 1

Substitution of (3.11)-(3.14) into (3.17) yields with simplification

$$D = -(\Delta_2)^2(1 + k^2) + \Delta_2(k - 1)(1 - 2p^0) - 2(\Delta_1)^2. \tag{3.31}$$

Weight manipulation is more profitable than myopic pricing whenever (3.31) > 0. Differentiating the expression in (3.31) with respect to Δ_2 gives

$$\frac{\partial D}{\partial \Delta_2} = -2\Delta_2(1 + k^2) + (k - 1)(1 - 2p^0) = 0 \text{ at a maximum, so}$$

$$\Delta_2^* = \frac{(k - 1)(1 - 2p^0)}{2(1 + k^2)}. \tag{3.32}$$

To verify that this value of Δ_2 is a maximum, notice that $\frac{\partial^2 D}{\partial(\Delta_2)^2} < 0$. Substituting (3.32) into (3.31) and simplifying gives

$$D = \frac{(k - 1)^2(1 - 2p^0)^2}{4(1 + k^2)} - 2(\Delta_1)^2. \tag{3.33}$$

The expression in (3.33) may be restated as

$$D = \frac{(1 - 2p^0)^2}{4}\left(\frac{(k - 1)^2}{(k - 1)^2 + 2k}\right) - 2(\Delta_1)^2. \text{ Q.E.D.} \tag{3.34}$$

Proof of Proposition 2

The proof demonstrates in two steps that, for any $\Delta_1 \in (0, p^0]$ and $p^0 \leq 0.21$, weight manipulation is profitable. The first step establishes that the net revenue to the firm from manipulating the weights increases as the price-cap decreases. The second step involves finding for each $\Delta_1 \in (0, p^0]$ the smallest p^0 that ensures no financial gain to the firm from weight manipulation. Given the first step, we can conclude that weight manipulation will be profitable for all p^0 below the p^0 that is constructed for any selected Δ_1.

From (3.34), define

$$Z(\Delta_1, p^0) = \frac{(1-2p^0)^2}{4}\left(\frac{(k-1)^2}{(k-1)^2+2k}\right) - 2(\Delta_1)^2. \tag{3.35}$$

Substituting for k from (3.3) and (3.15) provides

$$Z(\Delta_1, p^0) = -2(\Delta_1)^2 + \frac{(\Delta_1)^2\left(-1+2p^0\right)^4}{2\left((\Delta_1)^2\left(1+(\Delta_1)^2\right)+6p^0(\Delta_1)^2\left(p^0-1\right)+\left(p^0\right)^3\left(p^0-2\right)\right)}. \qquad (3.36)$$[4]

Note that

$$\frac{\partial Z(\Delta_1, p^0)}{\partial p^0} = \frac{(\Delta_1)^4(-1+2p^0)^3\left(1+4(\Delta_1)^2+p^0(1-p^0)\left(\frac{1-12(\Delta_1)^2}{(\Delta_1)^2}\right)\right)}{2\left((\Delta_1)^2\left(1+(\Delta_1)^2\right)+6p^0(\Delta_1)^2(p^0-1)+(p^0)^3(p^0-2)\right)^2}. \tag{3.37}$$

The denominator and the first term in the numerator of the expression in (3.37) are clearly positive. The cubic term in the numerator of (3.37) is negative for all inelastic demand (i.e., $p^0 < 0.5$). The third term in the numerator of (3.37) can be shown to be positive for any Δ_1 and p^0 such that $0.5 > p^0 \geq \Delta_1 > 0$. Let

$$N = \left(1+4(\Delta_1)^2+p^0(1-p^0)\left(\frac{1-12(\Delta_1)^2}{(\Delta_1)^2}\right)\right), \tag{3.38}$$

such that N = N1+(N2*N3), where

$N1 = 1 + 4(\Delta_1)^2$,

$N2 = p^0(1-p^0)$, and

$N3 = \left(\frac{1-12(\Delta_1)^2}{(\Delta_1)^2}\right)$.

---

[4] The derivative of (3.36) with respect to D_1 involves powers of D_1 up to the eighth order. There is no apparent analytical solution for the optimal first-period price change.

N1 > 0 and N2 > 0 for all $p^0 \in (0, 0.5)$ and $\Delta_1 \in (0, p^0]$. Note that, for any $\Delta_1 \leq \sqrt{\frac{1}{12}} \cong 0.289$ and $p^0 \in (0, \frac{1}{2})$, N3 > 0 and, thus, N > 0. For N to be positive everywhere, we need only show that N > 0 whenever N3 < 0 for all $\Delta_1 \in (0.289, p^0]$ and $p^0 \in (0.289, 0.5)$. In general, the expression in (3.38) may increase or decrease in Δ_1:

$$\frac{\partial N}{\partial \Delta_1} = 8\Delta_1 - 2(\Delta_1)^{-3} p^0(1-p^0) \gtreqless 0. \tag{3.39}$$

For the case where N3 < 0 for all $\Delta_1 \in (0.289, p^0]$ and $p^0 \in (0.289, 0.5)$, it is straightforward to verify that the expression in (3.39) ≤ 0 with a trivial equality only as $\Delta_1 \to p^0$ and $p^0 \to 0.5^-$. Also, for any $\Delta_1 \in (0, p^0]$ and $p^0 \in (0, \frac{1}{2})$,

$$\lim_{\Delta_1 \to 0} N = +\infty,$$

$$\lim_{\substack{\Delta_1 \to p^0 - \\ p^0 \to 0+}} N = +\infty \text{ ; and,}$$

$$\lim_{\substack{\Delta_1 \to p^0 - \\ p^0 \to 0.5-}} N = 0 \ .$$

Thus, the expression in (3.38) is positive and decreasing in Δ_1 for all $\Delta_1 \in (0.289, p^0]$ and $p^0 \in (0.289, 0.5)$, and the expression on the right-hand-side of (3.37) is strictly negative whenever demand is inelastic ($p^0 < 0.5$). Therefore, if $Z(\Delta_1, p^0) = 0$ for some $\Delta_1 > 0$ and some $\tilde{p}^0 \in (0, \frac{1}{2})$, then $Z(\Delta_1, p^0) > 0$ for all $p^0 < \tilde{p}^0$.

It remains to show that $\exists\ \Delta_1 \in (0, p^0]$ such that $Z(\Delta_1, p^0) = 0$. When the expression in (3.36) is set equal to zero, p^0 may be expressed as a function of Δ_1. Setting the expression in (3.36) equal to zero and rearranging gives a quartic polynomial in p^0:

$$\begin{aligned}&(\Delta_1)^2 - 4(\Delta_1)^4 - 4(\Delta_1)^6 + p^0\left(24(\Delta_1)^4 - 8(\Delta_1)^2\right) + \\ &(p^0)^2\left(20(\Delta_1)^2 - 24(\Delta_1)^4\right) - 24(\Delta_1)^2(p^0)^3 + 12(\Delta_1)^2(p^0)^4 = 0.\end{aligned} \tag{3.40}$$

7 quartic polynomial has at most four roots (see Lax (1991) p. 177). The four possible solutions of the expression in (3.40) for p^0 are given by

$$p^0 = \frac{1}{2} - \frac{1}{12}\sqrt{-12 + 144(\Delta_1)^2 + 24\sqrt{1 - 12(\Delta_1)^2 + 48(\Delta_1)^4}}\ , \tag{3.41}$$

$$p^0 = \frac{1}{2} + \frac{1}{12}\sqrt{-12 + 144(\Delta_1)^2 + 24\sqrt{1 - 12(\Delta_1)^2 + 48(\Delta_1)^4}}\ , \tag{3.42}$$

$$p^0 = \frac{1}{2} - \frac{1}{12}\sqrt{-12 + 144(\Delta_1)^2 - 24\sqrt{1 - 12(\Delta_1)^2 + 48(\Delta_1)^4}} \text{ ; and,} \tag{3.43}$$

$$p^0 = \frac{1}{2} + \frac{1}{12}\sqrt{-12 + 144(\Delta_1)^2 - 24\sqrt{1 - 12(\Delta_1)^2 + 48(\Delta_1)^4}}\ . \tag{3.44}$$

For any $\Delta_1 \in (0, \frac{1}{2})$, only the expression in (3.41) yields $p^0 < 0.5$.[5] Notice that for the expression in (3.41)

$$\frac{\partial p^0(\Delta_1)}{\partial \Delta_1} = \frac{\left(\frac{12\Delta_1\left(1-8(\Delta_1)^2-\sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}\right)}{\sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}} \right)}{\left(\sqrt{-12+144(\Delta_1)^2+24\sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}} \right)} < 0 \;\forall\; \Delta_1 \in (0, \tfrac{1}{2}). \quad (3.45)$$

The denominator of the expression in (3.45) is positive The denominator of the fraction in the numerator of (3.45) is also positive. The sign of (3.45) hinges on that of the fraction in the numerator of (3.45). Let

$$M = \left(1 - 8(\Delta_1)^2 - \sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}\right). \quad (3.46)$$

Then

$$\frac{\partial M}{\partial \Delta_1} = \Delta_1\left(-16 + \frac{12\Delta_1(1-8(\Delta_1)^2)}{\sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}} \right) < 0 \;\forall\; \Delta_1 \in (0, \tfrac{1}{2}). \quad (3.47)$$

At the extreme values of Δ_1 ,

$$\lim_{\Delta_1 \to 0.5^-} M = -2 \text{ ; and,} \quad (3.48)$$

$$\lim_{\Delta_1 \to 0^+} M = 0 \text{ .} \quad (3.49)$$

By (3.47), (3.48), and (3.49), the expression in (3.46) is negative and decreasing in Δ_1 for all $\Delta_1 \in (0, \frac{1}{2})$. Since (3.46)< 0, it follows directly that (3.45) < 0. Since (3.45) < 0, the smallest p^0 that ensures no financial gain to the firm from weight manipulation is given by the value of the expression in (3.41) as $\Delta_1 \to 0$:

$$\lim_{\Delta_1 \to 0}\left(\tfrac{1}{2} - \tfrac{1}{12}\sqrt{-12+144(\Delta_1)^2+24\sqrt{1-12(\Delta_1)^2+48(\Delta_1)^4}} \right. = 0.211 \quad (3.50)$$

Therefore, by (3.37), for all $p^0 < 0.211$, $\exists\; \Delta_1 \in (0, p^0]$ such that $Z(\Delta_1, p^0) > 0$.

Q.E.D.

Proof of Proposition 3

For the case where demand is not totally inelastic, substitution of (3.11)-(3.14) into (3.4) and (3.5) yields with simplification

$$\Delta S \quad = S[\Delta_1 > 0, \Delta_2 > 0] - S[\Delta_1 = 0, \Delta_2 = 0],$$

---

[5] The expression in (3.42) results in $p^0 > 0.5$. Expressions (3.43) and (3.44) do not yield real solutions.

$$\Delta S = -(\Delta_1)^2 - 0.5\,(\Delta_2)^2 - 0.5\,(\Delta_2)^2\,k^2 + \Delta_2\,p^0\,(1-k) < 0. \tag{3.51}$$

With prices as in (3.11)-(3.14), k > 1 under revenue weights, so all terms in (3.51) < 0.

With quantity weights, let second-period weights and prices be those from Lemma 4, i.e.,

$$p^{AQ}_1 = (p^0 - \Delta_1), \text{ and} \tag{3.52}$$

$$p^{BQ}_1 = (p^0 + \Delta_1), \text{ so} \tag{3.53}$$

$w^{AQ}_2 > 0.5 > w^{BQ}_2$ (by Lemma 3).

Using (3.7) gives

$$p^{AQ}_2 = (p^0 - \Delta_2), \tag{3.54}$$

$$p^{BQ}_2 = (p^0 + k\Delta_2), \text{ and} \tag{3.55}$$

$$k = (w^{AQ}_2/w^{BQ}_2) > 1, \tag{3.56}$$

so all terms in (3.51) < 0.[6]

When demand is totally inelastic, let $x\,[p^0] = 1$. In this case, it is straightforward to verify that by pricing non-myopically the firm gains and consumers lose the area $\Delta_2(k-1)$, where k > 1 under revenue weights or quantity weights, i.e., (3.5) or (3.56). Q.E.D.

Proof of Proposition 4

Substitution for k from (3.15) and (3.19) into (3.34) gives with simplification

$$D = \frac{(\Delta_1)^2\left(-3 - 4(\Delta_1)^2 + 4p^0\right)}{2\left((1-2p^0) + (\Delta_1)^2 + (p^0)^2\right)}. \tag{3.57}$$

The denominator of the expression in (3.57) is always positive when demand is inelastic. The numerator of (3.57) is always negative since $-3(1 - 4/3p^0) < 0$ for all $p^0 \in (0, \frac{1}{2})$. Therefore, myopic pricing is always the most profitable strategy under quantity weights when demand is inelastic. Q.E.D.

---

[6] The expression in (3.51) is not sensitive to which service is labeled "A" since the market demands are identical. An equivalent setup for quantity weights is to let p^{AQ}_2, p^{BQ}_2, and k remain the same as in (3.11)-(3.15). Setting $p^{AQ}_1 > p^0 > p^{BQ}_1$ gives $w^{BQ}_2 > 0.5 > w^{AQ}_2$, so $k = w^{BQ}_2/w^{AQ}_2 > 1$ (by Lemma 4) and (3.51) < 0. Q.E.D.

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